Questioning Inevitability of Energy Pathways: Alternative Energy Scenarios for California

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by Rebecca Ghanadan
rebeccag@socrates.berkeley.edu
The Energy and Resources Group
University of California Berkeley

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Introduction

> *"Someone in the state needs to be thinking about where we want California to be in 2025."*
>
> *"We are going to be living with the effects of recent events (in California) for a long while."*
>
> *"Energy is technical, energy is economic, and energy is deeply infused with public interest"*

These comments from a recent forum on energy[1] speak to the strong need for long-term and interdisciplinary approaches to energy policy and planning. Blackouts and high energy prices in California, recently brought energy issues to the forefront of mainstream concern across the U.S. But while the visibility of energy crises can point out immediate inadequacies, it also implicates deeper needs for innovative and systematic approaches to energy analysis – both within California and in other domestic and international contexts.

Developing a long-term energy policy framework requires systematic information that can clearly connect understandings of current choices, uncertainties, and driving forces to the range of possible pathways and outcomes for the future. Significantly, however, many energy analysis approaches offer narrow and highly specific information which is not very accessible to non-expert audiences and is poorly equipped to explore alternative outcomes. For example, long-term energy and fuel forecasts provide detailed information about current expectations for the future based on current patterns. However, they offer very little insight into processes of change or contexts which might motivate change. This disconnect between the type of information typically offered by energy analysis and the type of information that is needed to connect energy choices to their broader context and implications reinforces a fragmented approach to energy policy and planning. Energy analysis methods which can integrate between long-term visioning and current choices are critically needed to bridge the chasm between immediate priorities and desired outcomes.

The point of entry for this project is deeply informed by the need for new approaches to energy analysis. This project presents energy scenarios as a useful approach for visualizing and critically engaging with future possibilities. Developing a set of methods and energy scenarios for California, this project highlights scenario analysis as a systematic and exploratory way of thinking about energy from a long-term perspective. It aims to inspire critical discussion about energy choices in a way that is accessible and interesting to a broad base of stake-holders and decision-makers. This project offers a starting point for considering alternative energy pathways for California.

Focusing on Energy Pathways

In this paper, the term "energy pathway" is used as an umbrella concept to describe how an energy system develops over time. Embedded in this term are two layers of meaning which are conceptually important to recognize. First, energy pathways represent trajectories of energy characteristics over time. For example, the pattern of total energy consumption in California over the last fifty years is one element of California's energy pathway. In the second layer, energy pathways also embody a set of relationships between social, technical, and economic processes that underlie observed energy patterns. Historical and future energy patterns are more than statistics and technologies that are manipulated by policy or acted on by simple driver parameters. They arise out of particular conjunctures of social, economic, and political processes operating within the constraints and possibilities of existing physical, technological, and institutional structures. For example, during the oil crisis of the 1970's, political, social, and economic

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[1] The *Forum on the Future of Renewable Energy in California* was hosted by the Renewable Energy Policy Project at the Haas School of Business at University of California Berkeley in October 2001.

forces converged in a way that radically changed the trajectory of energy consumption and energy intensity in California and the U.S. – these changes continue to profoundly affect energy patterns of today. Conceptualizing energy systems in terms of energy pathways acknowledges both observed outcomes and their underlying driving forces.

Energy pathways are a conceptual starting point for thinking about future energy scenarios. Scenarios are plausible and interesting stories about how the future may unfold. Both the process of developing sets of alternative scenarios and the outcomes they generate can inspire critical thinking and illuminate options in times of uncertainty. Energy scenarios open the doorway to possibilities for change and focus attention on a range of potential alternatives. Energy pathways and scenario methods move beyond deterministic or predictive understandings of the future. Energy pathways enable energy systems to be understood as dynamic - constantly being reformed and shaped by society and technology over different time and spatial scales. Energy scenarios provide a means of exploring these alternative pathways. This approach acknowledges that multiple trajectories for the future exist and are relevant to the present. By opening the door to possibilities, scenarios provide an initial step toward questioning inevitability of energy pathways. Energy scenarios are an enabling approach that focuses value and attention on choices and opportunities in the present. It is the kind of perspective that is needed if California is to actively engage with the challenges and opportunities posed by its current energy system and be a leader and innovator in energy.

The California Context

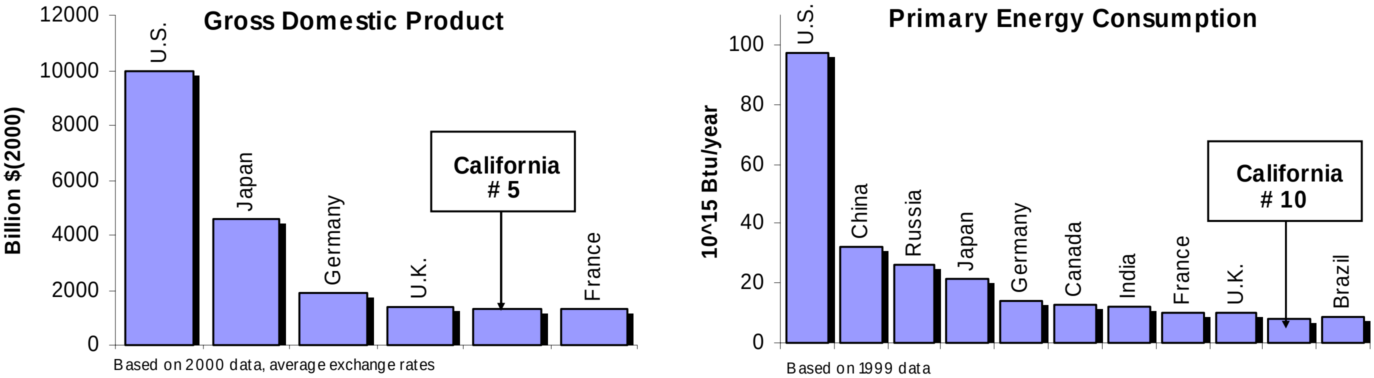
California currently faces an important cross-road in its energy pathway. Emerging from the electricity crisis of 2000 and 2001, many aspects of the state's vision for the future have unraveled. The expectations for how electricity deregulation would shape the state's energy system were turned on their head by the energy crisis, leaving in their place a context of profound uncertainty about the future. The causes and effects of these events will continue to be interpreted and discussed for many years. However, this analysis is interested in directing attention toward a different set of important questions. *How will the state move forward? What priorities will shape California's energy system over the next twenty years? How might leadership emerge? How is it possible to critically engage with the future in order to make better decisions today?* In California, a unified and integrated vision for the future has yet to come into view making the present a critical time to initiate systematic and strategic thinking about the state's priorities and future energy pathway. Scenarios are a useful approach for beginning this process.

A State with Regional, National, and International Significance

California is home to more than thirty-three million people, possesses a wealth of natural resources, and comprises the fifth largest economy in the world. Balancing the energy needs of this populous and productive state with desired social and environmental outcomes is a challenging task that involves numerous interconnections and trade-offs between economic, environmental, and political priorities. The future may unfold in many different ways, and how the state responds to these uncertainties and opportunities will have enormous impacts both within the state and in other domestic and international contexts.

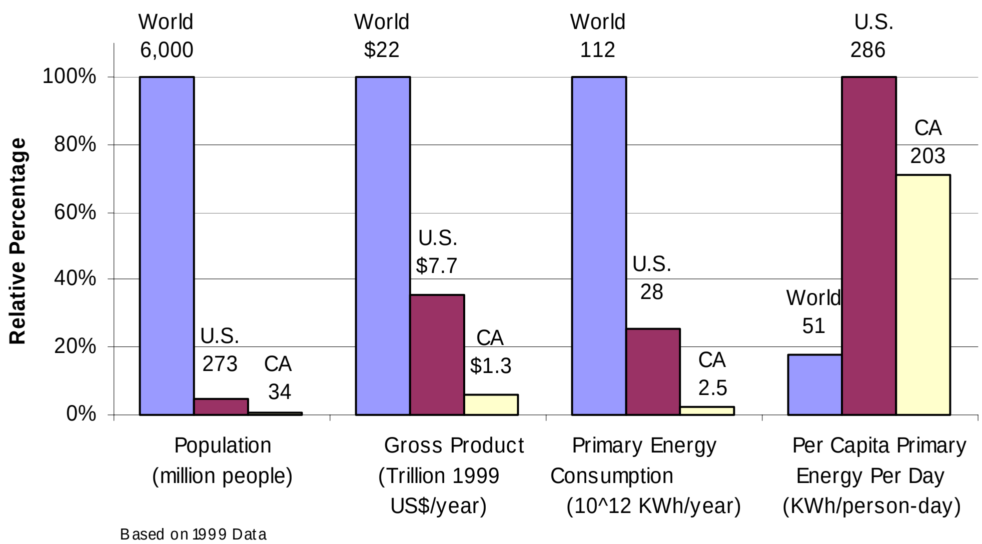
In terms of the size of its population, its standard of living, and level of resource use, California is comparable to the most developed countries in the world. California is the fifth largest economy in the world and ranks tenth in world energy consumption.

Figure i.1 California Ranks Among the Most Developed Countries



California also consumes a significant share of world resources. The state is responsible for using more than 6% of world goods and services and 2% of world primary energy while having only 0.6% of the world's population. In terms of per capita consumption, the average Californian consumes about four times the energy of the average person in the world. In comparison, the average American consumes closer to six times the energy of an average world citizen.

Figure i.2 California's Production and Consumption Exceed Its Population Share



In the context of global climate change, California is also a major player. The average Californian is responsible for about three times the carbon dioxide emissions of the average world citizen[2]. As with energy consumption, per-capita emissions are less that the U.S. average. California ranks approximately 15th in terms of carbon dioxide emissions. Including out-of-state fuel generation, California would likely rank between 5th and 10th globally.

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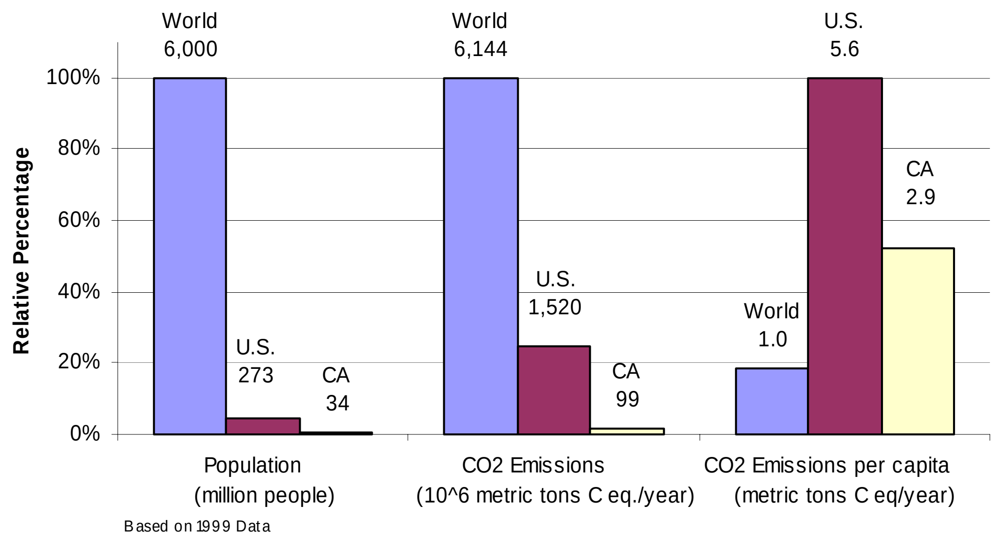
[2] The CO_2 emissions data presented here reflect only in-state emissions. Since California imported almost 30% of its electricity in 2000 from out of state sources, these numbers underestimate emissions associated with actual energy consumed in the state. More than 30,000 GWh of electricity was imported from coal-fired power plants located outside of the state in 2000, which, if included, would significantly increase state total and per capita CO_2 emissions.

Figure i.3 California is an Important Player in Global Carbon Dioxide Emissions



Considered a leader and example in terms of energy, choices in California have a formative influence outside of the state as well. The state has historically been on the forefront of energy policy and technologies. In many cases, California has been an example and experimental context for potential energy policy and activities. Perhaps the most important recent example is the electricity crisis of 2000 and 2001. California is one of the most visible and highly scrutinized electricity systems to deregulate in the world. The interpretation of California's deregulation experience outside of the state will have far reaching implications for how deregulation policies and decision are carried out in other states and countries.

Both the uncertainty and significance of California's energy context are important motivations for considering how the state's energy future may unfold. This paper presents a framework for examining alternative future energy pathways. With California as an important world energy player, this analysis aims to inspire discussion and critical engagement with future energy choices of a state whose influence has far reaching implications across regional, national, and international scales.

Scope of Analysis

There is a substantial body of literature examining specific dimensions of California's energy system, for example market analyses, energy and price forecasts, and energy efficiency studies. The California Energy Commission regularly reports reviews of sector and fuel trends. The California Air Resources Board focuses on air quality dimensions of energy use and has developed a detailed model of emissions from mobile sources. The U.S. Department of Energy provides a detailed fuel balance for each state. State utilities and consultants have conducted end-use studies and program reviews. Advocacy organizations provide analysis directed at particular policy options. Added to this mix, a recent flurry of articles and reports across agencies, newspapers, and journals have attempted to analyze and interpret the implications of California's recent electricity crisis. Many of these documents are found in the bibliography.

In terms of scenarios, there are two types of literature that are relevant to this analysis. First, a substantial body of writing comes primarily out of business and management literature, and focuses on use of scenarios as a strategic management and organizational learning tool. This literature elaborates how the process of developing scenarios can create a learning environment and generate critical insights into strategic decision making. Many of the prominent figures in this area come from a core group of ex-Royal

Dutch/Shell scenario planners who now articulate and present scenario techniques to a wider audience. Perhaps most notably, Peter Schwartz and his popular book, *The Art of the Long View*, has become one of the most widely recognized and widely cited books on the topic of scenarios. (Schwartz, 1992)

The second area of scenario literature that is important to this analysis is the increasing body of work on energy scenarios. The term "scenarios" within the energy analysis literature has a much looser meaning than the detailed scenario development process of the business literature. Scenarios in energy analysis include a range of different interpretations of the term, from scenarios referring to high/low limits on forecasts to assumptions energy efficiency potentials. Some of the most important scenarios have come out of work on climate change and energy efficiency. Climate Change Emissions Scenarios of the Intergovernmental Panel on Climate Change play a central role in both climate change science and policy. (for example, see Nakicenovic and Swartz, 2000) Another important energy scenario effort is the recent report, *Scenarios for a Clean Energy Future,* prepared by an interlaboratory working group of U.S. national labs. (Interlaboratory, 2000) This report analyzes the effects of three different public-policy scenarios on the growth of energy consumption and carbon dioxide emissions over the next twenty years. Both of these examples reflect a growing effort within energy analysis to address uncertainty and incorporate broader dimensions of society and technological change into their scope of analysis

This analysis draws on both of these bodies of literature to develop an integrated approach that incorporates both a detailed process for developing scenario stories and a set of analytical techniques for evaluating scenario outcomes. For a scenario planner, this project is surprisingly analytical. For an energy researcher, it may seem surprising to incorporate imagination and narrative. The element of surprise to both sets of readers is deliberate. The aim of this work is to present a unique an integrated approach for thinking about energy scenarios which challenges energy analysis to be exploratory and scenario planning to be robust.

Currently, this project is the only comprehensive effort to develop energy scenarios in California. In the highly uncertain environment coming out of the energy crisis, now is a critical time for the state to develop a vision about the future. Scenario analysis offers a particularly useful approach in this context. This paper takes a step back from the single sector, fuel, emissions, or policy analysis approach used in the majority of the state-level energy literature in order to bring the broader context of California's overall energy pathway into view. This paper keeps an eye to the big picture of how energy is used and understood in California while exploring different ways that the future may unfold. It represents an attempt to think systematically and critically about broad processes, driving forces, and important factors while situating these concepts within the context of actual energy choices and priorities. The aim of this analysis is to use scenarios to provide a starting point for new methods and critical discussion about the future.

Underlying the set of scenario analysis methods and results presented in this paper are four key claims that are useful to make transparent. First, this paper asserts that scenarios offer a valuable energy analysis method for thinking systematically about processes of change. Second, it shows that the process of developing and creating scenarios leads to more robust understandings of energy dynamics and opportunities for the future. Third, it asserts that the alternative scenarios developed for California in this paper are examples of the numerous plausible and interesting alternative energy pathways that exist for the state. These examples call for additional and continued exploration of alternative energy pathways. Lastly, this paper shows that although scenarios do not show exactly what the future will be like, they can illuminate areas of priority and consideration for the present.

The analyses presented in this paper are organized around these claims. Section one introduces the scenario approach and situates this method within the context of energy analysis. It contrasts energy forecasts and scenarios and provides a foundation for using scenarios in the remainder of the paper. The second section presents a methodology for developing scenario stories and elaborates a business-as-usual and three alternative scenarios for California over the next twenty years. Building on the stories from the second section, the third section explores the form of California's future energy system under each set of scenario conditions. It describes the energy modeling framework used to evaluate fuel and energy use implications of each scenario on California's future energy system. This section considers the implications of the alternative scenarios for energy diversity and greenhouse gas emissions. The final section concludes with an outline of critical issues and policy implications illuminated by this analysis.

Section 1. Scenarios as a Method for Energy Analysis

1.1 The Uncertain Context of Long-term Planning

Planning and decision-making operate in a context characterized by risk, ambiguity, and uncertainty – and these uncertainties often generate a disconnect between immediate decisions and long-term desired outcomes. Strategic planning requires decisions to be made within contexts of uncertainty, and decision-makers need tools for evaluating present choices within a long-term perspective. Scenarios are a particularly useful approach weighing out options in this context.

The world is rapidly becoming more highly interlinked and by many measures more uncertain. Enhanced by information technologies, new forms of knowledge, and the ability of human activity to dramatically alter global systems, the decision-making environment has become more uncertain and complex. The importance of decisions involving complex, highly-linked systems like those involving energy, is enhanced by the interconnected nature of global welfare. Shared use of global resources links up the impacts of energy choices across geographies and across scales. Given the magnitude of contemporary human influence on the globe, individual planning choices are also global decisions. There are no separate solutions to the range of social, economic, and environmental challenges society faces. Group decision-making and effective planning on a global scale is needed to address many of the most critical challenges the world faces today.

1.2 Perspectives on the Future

Planning and decision-making are based on the idea better decisions are made if the nature of dynamic systems and their uncertainties can be better understood. However, individuals can have different perspectives and understandings of the future. Van der Heijden offers a useful framework of three competing perspectives – rational, evolutionary, and processual – to characterize how people think about the future. (1996) Different perspectives lead to different approaches to planning and decision making. Describing these different perspectives is useful for revealing the motivations and perspectives used in energy scenarios and situating these activities within the context of energy analysis.

Rational, evolutionary, and processual understandings of the world lead to different interpretations of planning and decision-making. A rational approach is based on an implicit belief that the world is predictable. The goal of planning is to get as close as possible to the "optimal" answer, which can be found with the right tool and proper insight. Engaging with the future is based on a strategy of "predict and control". This perspective lends itself to reliance on data, information, and analytical methods.

An evolutionary perspective develops strategy from looking retrospectively. Future outcomes are perceived too complex and uncertain to analyze in entirety, leading to an approach which relies on understandings of successful choices in the past to guide responses to immediate concerns. This perspective seeks knowledge from the historical record and has little predictive power.

A processual perspective focuses on understanding the interaction between systems and their uncertainties. It separates out those elements which are predetermined from those that are critical uncertainties. (Schwartz, 1992) This perspective focuses learning from the process of engaging with the future, rather than on obtaining specific answers and outcomes.

Competing interpretations of how the future will unfold emerge from these different perspectives. Wright (2000) suggests that most readings of the future fit one of the four key storylines outlined in the table below. These simple headings are surprisingly comprehensive in their ability to characterize a large proportion of both quantitative and qualitative analyses of the future.

Common Storylines about the Future	
Same But Better -	*"Incremental Future"*
Significantly Better -	*"Accelerated Future"*
Same But Worse -	*"Downward Sloping Future"*
Radically Different -	*"New Dimensions Future"*

The first three storylines ground themselves in trends that extend directly from the present. They lead to worlds where fundamental structures and driving forces are the same as today. They differ, however, in the extent and direction of their perceived outcomes. In contrast, the last storyline, "New Dimensions World" leads to a world that is fundamentally changed. Present and historical trends are irrelevant in the context of this radically different future. The radically different storyline embraces the idea that profound changes can and do occur, and that the future is often shaped from discontinuities rather than smooth trajectories.

Each perspective about the future – rational, evolutionary, and processual – gives different weight to each of these four possible storylines. For the rational perspective, "Accelerated Future" is the most important storyline. This way of conceptualizing the future reinforces the idea that the right tool can help achieve the most desirable outcome quickly while maintaining control. For the rational perspective, "Incremental Future" is an outcome which can be improved with better planning tools. "Downward Sloping Future" is the threat of poor planning and a key justification for rational planning. In contrast, an evolutionary perspective focuses on optimizing current choices and puts the most value on an "Incremental Future". This future links future possibilities to present and past patterns in a way that is incremental and measurable. Existing structures, trends, and driving forces become the most important sources of information for considering how the future may unfold.   In contrast to both of these perspectives, the processual perspective focuses on understanding a range of possible storylines.   It is the only perspective interested in considering a "New Dimensions Future". It is based on the idea that exploring alternatives leads to richer understandings and more effective engagement with future dynamics which will always be uncertain and not fully predictable.

Most techniques for examining future energy systems arising from the field of energy analysis are underpinned by a rational and evolutionary perspectives about the future. Energy forecasts, the most widely used technique for considering future energy pathways, aim to present "most likely pathways". These pathways usually take the form of an "Incremental Future" storyline extending current trends into the future using current expectations of growth or change. Forecasts are carried out by government agencies and business organizations which themselves function from highly rational and evolutionary perspectives on the world. Rational forecasting techniques are most successful in well defined contexts characterized by stable relations between driving forces where future patterns are relatively predictable. However, as planning contexts extend over longer time periods and dynamics become more uncertain, forecast methods become less effective.

Ideally, an integrated approach would be used to explore long-term energy pathways, drawing on rational, evolutionary, and processual perspectives to engage with future uncertainty. Scenario analysis is a valuable approach in this context. Scenarios develop understandings of a number of possible outcomes, thereby providing a framework for weighing current options against a range of possible outcomes. It is an integrative approach which builds on the learning focus from the processual perspective, tools from the rational perspective, and interpretations of past trends from the evolutionary perspective. Scenarios are energy analysis techniques that aim to develop decision-making strategy in what Schwartz (1992) calls "the full view of uncertainty".

Scenarios and forecasts both elaborate future pathways, however, their approaches, utility, and interpretations of the future are fundamentally different. The next section contrasts scenarios and forecasts in greater detail. The relationship between these two approaches is an essential dimension of situating the future scenarios developed later in this paper within a broader context of energy analysis.

1.3 One Future, Two Approaches: Energy Forecasts and Energy Scenarios

1.3.1 Contrasting Approaches

Energy forecasts and scenarios ask different questions about the future. Forecasts ask, *What is expected to happen given historical data and understandings of energy systems?* Inquiring in this way, forecast results reflect a "best guess" about the future based on the current understandings of the present and the past. In contrast, scenarios use an alternative approach, framing the question as, *How might key driving forces lead to different outcomes? What possible outcomes provide the most valuable insight to effective decision-making?* Scenarios develop a set of diverse, plausible stories about how the future may unfold. They are driven by an interest in engaging with uncertainty and imagining different realities in order to make better choices in the present. Forecasts strive for reasonable estimations and projections, while scenarios seek to facilitate strategic thinking and alternative visions. The table below compares these two approaches.

Table 1.1 Contrasting Energy Forecasts and Energy Scenarios

	FORECASTS	**SCENARIOS**
Driving Question	**What is likely?**	**What could be?**
Approach & Objective	Rational - focus on analysis & outcomes *To develop most likely pathway*	Processual - focus on process, strategy, learning *To develop insightful pathways*
Methods	Analytical models	Qualitative stories In some cases, modeling guided by stories
Storyline	"Incremental Future"	Emphasis on "New Dimensions Future" Numerous possible storylines
Treatment of uncertainty	- Probabilistic methods, - Transparency of assumptions	- Narrative exploration of critical uncertainties - Separation of predetermined & uncertain elements
Relevant Info & Important actors	Reliance on experts to do the best job - *Government agencies* - "Official Future" - *Large corporations* - contingency planning	Diverse thinkers, facilitators, & focus on interlinkages - *Business progressives* – want a piece of the future - *Forecast revisionists* – alternative assumptions - *Future advocates* - want to address concerns

Forecasts and scenarios incorporate uncertainty into their decision-making approach in different ways. Forecasts commonly predict a "most likely pathway" leading to a single future outcome. The decision-making premise is based on selecting options with the highest utility relative to forecast results. In order to select the most probable pathway, forecasts generally rely on experts – those thought to possess privileged knowledge and tools for accurately assessing probabilities and articulating the most likely outcome. This approach is based on the idea that appropriate tools and information can minimize uncertainty.

Scenarios, as they are used here, reflect alternative interpretations of how current trends and events may combine to create a variety of plausible outcomes. This approach separates what is considered predictable and predetermined from what is uncertain and ambiguous. Exploration of how the most important uncertainties may lead to different possible pathways and outcomes forms the basis of scenario planning. Scenarios provide an alternative approach to prediction of unpredictable aspects of a system. Rather, scenarios explore different stories about the elements considered least predictable. The decision making premise of scenarios focuses on selecting options that are the most strategically robust given a number of possible future conditions. This approach asserts that the process of developing plausible scenarios from predetermined elements, driving forces, and key uncertainties leads to new understandings and facilitates better decision-making. Using a scenario perspective, planning becomes a learning process. (van der Heijden, 1996) The fundamental difference between a forecasting and scenario approach is one of analysis versus strategy – forecasts aim for results while scenarios aim for learning.

1.3.2 Origins of Scenarios

Scenarios were first used in military war games in World War II to imagine potential enemy strategies and prepare alternative military tactical responses. The probabilistic forecasting techniques developed by RAND Corporation in the 1950's were some of the first formalized methods for addressing uncertainties associates with forecasts. RAND's Delphi Model replaced traditional single line forecasts with multiple trajectories that were assigned individual probabilities by groups of experts. In essence, these activities were based on a rational "predict and control" approach - uncertainty was treated as an attribute that could be controlled and characterized by experts and models.

The influence of RAND's early probabilistic methods can be found in high/medium/low limits that often accompany energy forecasts. In some cases, these limits are referred to as scenarios. However, this paper makes an essential distinction between forecasts and scenarios based on their different guiding perspectives and methodological approaches. Scenarios represent a process of developing "stories" about the future that use narrative to reflect possible outcomes arising from a particular conjuncture of predetermined and uncertain elements. In contrast, forecasts use a rational approach and expert tools to present a "best guess" future based on what is considered most likely. Using this definition, the high/medium/low limits around a forecast trajectory are not considered scenarios but rather forecast limits.

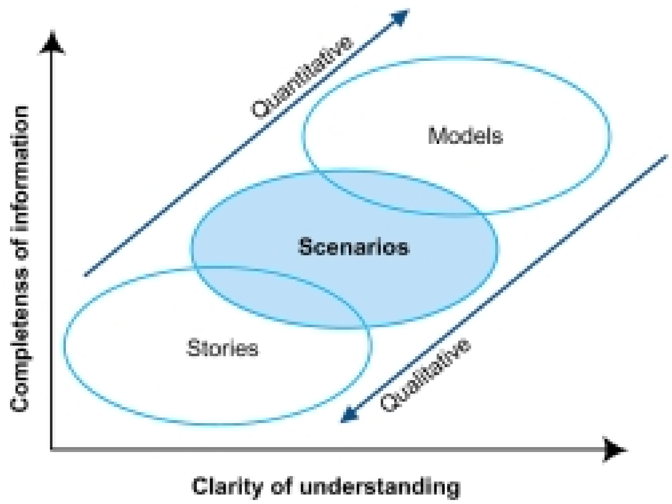
In the 1960's strategists at Royal/Dutch Shell, most notably Pierre Wack, began to question the effectiveness of probabilistic forecasts in addressing changing conditions. In numerous instances, forecasts had failed to prepare decision-makers for the range of possible conditions that they faced. Strategists at Shell began to ask, *What types of futures are not captured by probabilistic forecasts? How would decision-making strategy change if alterative futures were developed and treated as equally plausible?* Motivated by these questions, the strategy team at Shell began pioneering scenario techniques. Now, more than thirty years later, scenario planning methods have become incorporated in to the planning and decision-making activities of a large number of businesses and organizations.

According to numerous accounts, Shell's use of scenarios in decision-making helped the organization better anticipate and respond appropriately to changes (for example, see Schwartz, 1992, Gallopin and Raskin 1998) Notably, in the early 1970's, key Shell scenarios considered the possibility that oil prices could increase before the onset of the oil crisis. At this time, increasing prices seemed impossibility. Consideration of this "unlikely" option made Shell more prepared when the "impossibility" actually occurred. Another prescient example was a Shell scenario that described the "greening" of the Soviet Union during the early 1990's long before these trends became publicly visible. In both of these cases, the use of scenarios helped the organization make more effective decisions during changing conditions. The Shell scenarios did not predict events exactly as they occurred, in fact, scenarios should not attempt to be predictive. Instead, by representing many possible conditions, some of which became particularly visionary, the organization gained a better understanding of what was possible. In doing so, the organization was better able to think about changes and make more effective decisions because it had already imagined unexpected possibilities.

1.3.3 Stories and numbers: Contrasting forecasts and scenario methods

Future energy pathways can be described using both quantitative models and qualitative stories. The effectiveness of each method in describing energy pathways depends in large part on the level of information, understanding, and predictability of a given energy system. The figure below relates modeling methods to conditions of complete information and clarity of understanding. Quantitative techniques rely on developing rational understanding of complex systems. They are therefore most effective when systems are well defined and interrelations between factors are stable and predictable. In a more uncertain context, stories can capture the texture of possible conditions. Stories are positioned near the origin of the certainty space in the figure below, where information is incomplete and understanding are less clear. Scenarios span the intermediate conditions between extreme states, forming a bridge between qualitative and quantitative approaches. In this way, scenario methods are integrative, drawing on the intuition and causal relationships of stories and the systematic framework of interactions and outcomes of models.

Figure 1.1 Scenario Methods Integrate Stories and Models

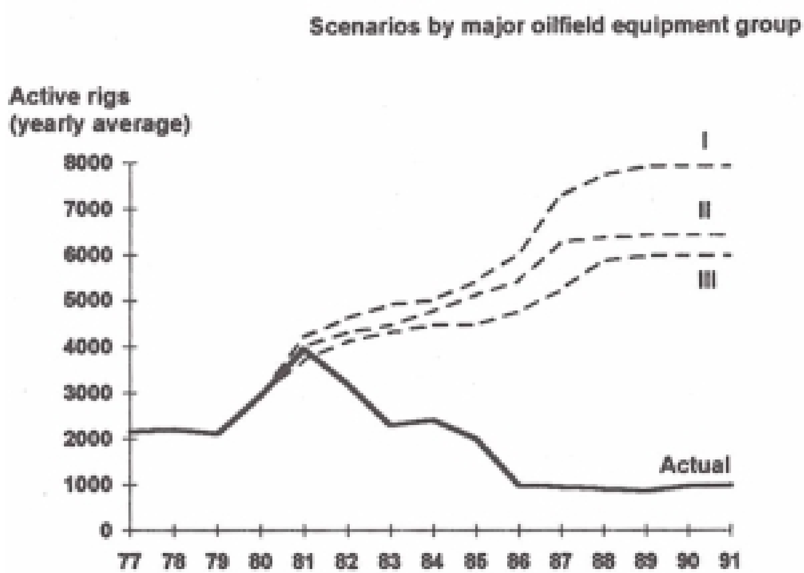


Source: (Shell 1999)

Energy forecasts are based on modeling methods which project, optimize, and/or evaluate probable trajectories of important parameters and indicators of an energy system. Forecast models use different analytical approaches, for example end-use, econometric, or trend analysis, however they are common in the fundamental way they engage with energy pathways. With a reliance on quantitative models and expert knowledge, forecasts are most commonly carried out by government agencies and large organizations with the authority, resources, and cadre of expert forecasters to develop these highly-analytical projections. Analytical modeling methods appeal to the rational perspective of managers, planners, technocrats and policy makers, reflecting the belief that it is possible to be in control. Founded on expert methods and implemented by authoritative actors, an interest in maintaining and portraying competence and stability underlies the general context for forecasting efforts. The incremental and evolutionary pathways most often generated from forecasts reinforce values of stability and continuity.

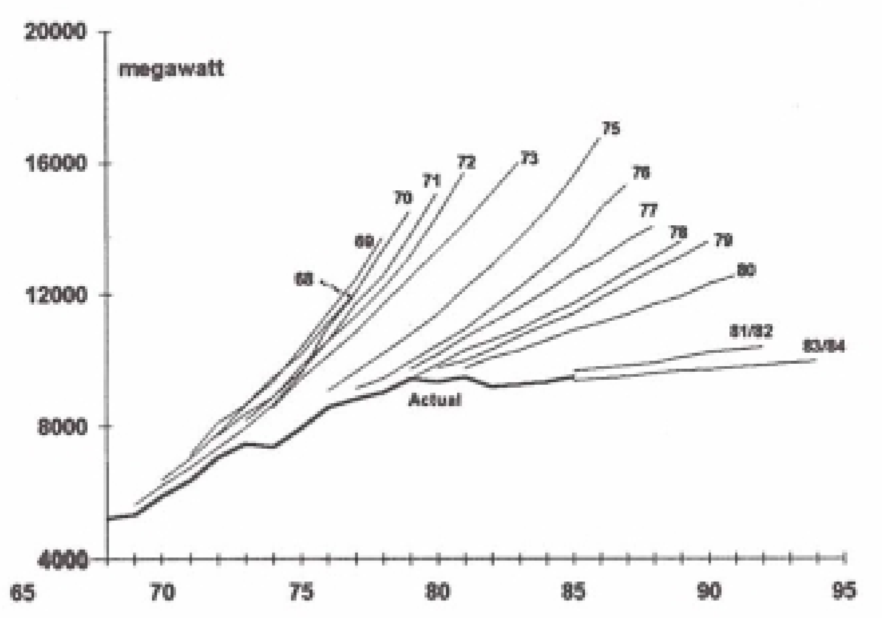
Optimized for stable conditions, forecast models have routinely failed under conditions of fundamental change. Under stable conditions, reasonable projections can be derived from a range of different underlying parameters. However under conditions of change, the complex interrelationship between driving forces are likely to change, rendering many models unable to represent emerging conditions. For example, the figure below shows how projections of oilfield drilling based only on forecasted oil prices failed to capture the effect of changing conditions. In this example, the elimination of federal depletion allowances, which provided significant incentives for oil-drilling before the early 1980's, dramatically reduced the number of active rigs despite increasing oil prices. The fact that these models were based on a few driver variables turned out to be insufficient to capture actual changes. (van der Heijden, 1996, 102)

Figure 1.2 Models Often Fail To Capture Critical Changes



Often the current expectations of future built into forecasting models limit their ability to perceive alternative futures. Current understandings of the present and the past maybe insufficient to engage with what Gallopin and Raskin call "inherent indeterminism of complex, dynamic systems." (1998) The systematic overestimation of electricity demand, and in particular, the inability of forecast models to effectively capture effects of changing consumer behavior and efficiency improvements inspired by the oil crisis of the early 1970's, demonstrate how forecasting approaches often fail under conditions of dynamic change. The following figure provides a nice example of models responding more to current expectations than to the reality of changing conditions. (van der Heijden, 1996, 96)

Figure 1.3 Forecasts Over Estimation of Power Consumption in the Netherlands



Scenarios rely on alternative stories about the future to explore uncertainty and develop better understandings of dynamic systems. Scenarios may also draw on modeling tools to quantitatively explore systematic changes and impacts of decision relative to a range of possible outcomes. By using "stories", scenarios can convey complex ideas in a way that is easy to understand and cognizant of the uncertain context of the future. Because of these features, scenarios are most often implemented by groups interested in anticipating future changes or proactively affecting future outcomes. This includes advocates of alternative pathways and institutions seeking to benefit from changing conditions. These motivations fundamentally challenge stability oriented futures, implying that historical trends can be rendered obsolete through the emergence of new conditions.

Scenarios are based on the idea that well-crafted stories make it possible to "suspend disbelief" about potential outcomes long enough to imagine different results, question dominant assumptions, and consider strategic decisions in the context of a range of possible outcomes. (Schwartz, 1992) Scenarios do not try to account for every possible outcome, rather they focus on developing a key set of insightful stories to highlight critical uncertainties and explore how these uncertainties may shape the future. Elaborating multiple possible outcomes through stories and models, scenarios provide a richer landscape for exploring and understanding possible future energy pathways.

1.3.4 Contrasting contributions

Both forecasts and scenarios offer different approaches and insights to energy analysis. In many ways, the benefits of both approaches are complementary. Forecasts offer interpretation of past and current patterns, characterization of key driver variables, and development of valuable analytical techniques. Carried out by government planning agencies, forecasting efforts motivate large-scale assembly of detailed data and surveys which facilitate a vast web of energy research. As well, government forecasts provide a description of what can be called the "Official Future". These forecasts serve as indicators of high-level planning priorities as well as a reference pathway for other research efforts. Significant energy research is facilitated by the extensive framework developed for government forecasts. The sharing and comparison of results, techniques, data, and assumptions of official and alternative forecasts make important contributions to the field of energy analysis.

Scenarios provide an important method for orienting long-term planning and energy analysis toward the future. Scenarios make it possible to evaluate what choices may be the most tactically sound in a variety of possible conditions. As well, the process of developing scenarios, particularly within a group or organizational context can provide a valuable method for developing shared visions and promote organizational learning. New understandings and interconnections arise out of the process of elaborating, negotiating, and exploring important factors and outcomes.

Scenarios acknowledge that the future is uncertain and offer a method for imagining and contrasting different choices and outcomes. In doing so, scenarios offer a unique approach which enriches the field of energy analysis.

1.4 Future Energy Scenarios in California

The background and contextualization of scenarios presented in this section are aimed at supporting the claim that scenarios are a valuable approach for considering future energy pathways. Scenarios broaden the scope of imagination and discussion surrounding energy alternatives. Building on the foundation of this claim, the remainder of this paper turns its attention to future energy scenarios in California. The scenarios presented in this paper combine conceptual stories with analytical modeling techniques to present three alternative and equally insightful energy pathways for California. The aim of this effort is to expand the envelope of possibilities and approaches used to consider energy alternatives and options.

California is in many ways at a crossroads in its energy pathway. Historical patterns have been broken by numerous changing conditions including deregulation, utility divestiture, the energy crisis, and crisis responses. How the future will unfold is highly uncertain. Since the completeness of information about California's energy future is low and the clarity of understanding is weak, scenarios provide an ideal approach for considering what the key opportunities and challenges of state will be. The research presented here presents a framework of ideas, tools, and examples which aim to inspire and facilitate critical engagement with the future of energy in California.

Section 2. Developing Future Energy Scenarios for California

Developing energy scenarios is a lot like practicing for a team sport. Practice does not make the actual game more predictable nor does it guarantee a desired outcome. Rather, practice is about rehearsing the types of interactions and situations that one may encounter later when the stakes are higher and the context is more critical. Practice builds skills and experiences to better anticipate and respond to dynamic situations. Players learn to work together and think strategically about the complex combination of conditions which make up situations. Developing energy scenarios serves this same function. Scenarios provide a way to interact and gain experience in different contexts. These situations will likely never play out exactly as they are rehearsed. However, the insights and experiences gained from developing scenarios afford a greater facility in interacting with dynamic conditions. Successful energy planning requires the ability to understand and respond to dynamic contexts. Scenarios provide a means of practicing for the future.

This section develops a set of future energy scenarios for California using a methodology adapted from Schwartz (1992). After introducing the key scenario development steps, it details the process followed to create alternative energy scenarios for California. Underlying these efforts is the claim that scenario development offers an opportunity for learning. By revealing preconceptions about the future and potentially challenging those ideas, scenario development can inspire critical engagement with diverse possibilities which may otherwise be passed over. Ideally, scenario development uses a participatory process to elaborate, negotiate, synthesize, and challenge the foundational assumptions of future pathways, yielding a truly creative process. Through group decision-making, new ideas, understandings, and connections are often made. Proponents of scenario methods claim that group learning is the key contribution of effective scenario planning.

This research focuses on developing an initial framework of qualitative and quantitative scenarios that explore California's energy future. The aim of these efforts is to provide ideas and tools which will inspire and facilitate renewed consideration of systematic and long-term dimensions of energy pathways in California. The framework presented in this section represents a useful approach for participatory and individual scenario development efforts.

2.1 A Methodology for Developing Energy Scenarios

How might California's energy pathway unfold? What might the critical turning points be? What stories about the future are plausible and interesting to think about today? In order to engage with these questions, this research takes on a scenario analysis approach. The six step process presented below forms the methodological basis for developing a set of alternative energy scenarios for California.

Steps in Developing Scenarios	
1.	Define a focal issue
2.	List important forces in the environment
3.	Evaluate forces by importance and uncertainty
4.	Select a scenario logic
5.	Develop scenarios around critical uncertainties
6.	Consider the implications of the scenarios

Adapted from (Schwartz, 1992)

This section shows how these steps are used to develop a set of different and interesting stories about the future. By detailing the methods used to develop the scenarios, the aim is to provide a deeper understanding of the stories, elaborate their underlying assumptions, and highlight points of interrelation.

2.2 Step One: Defining a focal issue

Scenario development begins by identifying a unifying question or idea to define what the scenarios will explore. The focal issue is what you want scenarios to tell you. Scenarios never answer the focal question definitively, rather they creatively and systematically engage with the context posed by the focal ideas. The focal issue provides an organizing lens for evaluating and assembling relevant information. (Schwartz, 1992) It can be specific or broad depending on the objective of the scenario analysis. When considering complex systems, defining a focal issue is essential. The focal issue used for the California analysis is a broad and systematic inquiry about clean energy and possible alternative pathways.

California Energy Scenarios Focal Issue –

How might "cleaner" energy technologies develop in California? What new priorities may emerge over the next twenty years? How might they influence California's energy pathway? Could California's energy system differ from business-as-usual expectations?

Considering how the future may differ from present trends and what role clean energy may take in the future are important and pertinent issues in California, particularly in the highly uncertain post-deregulation context. Profound changes over the last decade, beginning with deregulation and most recently following the "Energy Crisis" call for exploration of alternatives to business-as-usual (BAU) pathways. This analysis looks at different ways clean energy may become a more important force in the state. It avoids a "good world" vs. "bad world" approach for thinking about possibilities and alternatives. Rather, this analysis focuses on mixed world scenarios which explore possibilities and tensions rather than absolute potentials. Using scenarios as a learning tool, these mixed world scenarios provide greater sensitivity to trade-offs and dynamic interactions which guide real world contexts. Considering cleaner energy scenarios and their requisite trade-offs highlights how the development process is highly uneven and intimately affected by social choices. Scenarios provide a means for considering diverse dimensions of the future in a systematic way.

2.3 Step Two: Determining the Important Factors in the Environment

Armed with a compelling question and an important system to investigate, the next step in developing scenarios is to elaborate important factors in California's energy system. The highly interconnected nature of the energy environment results in a complex network of social, economic, political, and technological factors. The following table presents an extensive but certainly not exhaustive list of important factors influencing California's energy system.

Creating the list of important factors serves to define the universe of interactions and forces which may be considered in the scenarios. It is also useful to determining and assembling relevant information to the analysis. The list is, of course, too long to consider each item individually in each scenario. It becomes, thus important to identify the most important factors and critical dimensions for the future.

Table 2.1 Factors Influencing California's Energy Pathway

Form and Function of Post-Deregulation Energy System
- Organization and clarity of regulatory regime
- Form of power purchase/market structure
- Role of competition versus selecting "winners"
- Cooperative versus antagonistic relations –federal and state government, business, public, individuals

Decision making context
- Priorities and interests driving energy policy
- Decision-making context – strategic planning versus immediate responses
- Dominance of short-term economic costs over other considerations (air quality, energy diversity, etc.)
- Salience of long timescale impacts and outcomes
- Integration of long-term planning in decision-making
- Emergence of a shared vision of the future
- Public, industry, municipal influence in policy

Energy leadership
- Importance of state identity as energy leader/innovator
- Critical support and common understandings for action
- Agents of leadership – public, municipalities, state, federal
- Priorities driving leadership (developing new industry, climate change mitigation, re-deregulation, etc.)
- Macro- versus micro- solutions
- Form of leadership – policy, technology, institutions, justice

Energy linkages and understandings
- Prominence and interpretations of security-energy linkages
- Interpretations of deregulation and "The Energy Crisis"
- Domestic, state, and local salience of climate change
- Assessment of nuclear energy benefits and risks
- Fragmentation or integration of environmental concerns – air, water, land
- Understandings of consumerism and conservation
- Influence of free-market ideology

Geography-Energy-Political Linkages
- Reliance on electricity imports from other states
- Influence of natural gas producing states within California
- Accessibility and cost of Middle East oil
- Prominence political crises links to energy resource crises
- Political and public interpretation of U.S. oil dependence
- Influence of local, regional, and international conditions on state energy context

Energy Priorities
- Salience of priorities to different agents – individuals, public, business, government (local, state, federal)
- Cooperation and tensions between priorities
- Support for renewable energy and energy efficiency
- Concern and awareness of transportation impacts
- Interest in increasing energy diversity
- Perception of distributed generation benefits/costs
- Energy independence versus interconnection
- Interpretation of distributed generation and air quality impacts
- Relevance of climate change mitigation concerns
- Balance between supply and demand focus
- Potential implementation of Carbon taxes

State Government
- Strength of state energy regulatory authority
- Distribution of power and level of cooperation between branches agencies
- Effectiveness of structure and authority
- State versus federal regulatory control

Population and the Public
- Increasing population, significant ethnic diversity, increasing economic inequality
- Increasing home construction, home size, number of technologies in homes – computers & appliances
- Form of public interest/sensitivity to energy issues
- Public approval and trust in government and/or markets
- Public view of energy choices as personal responsibility versus paternalistic provision
- Public consensus versus fragmentation on energy topics
- Strength of community, consumer, non-government organizations
- Perception of transportation – driving as a right or responsibility
- Public perception and consumer preferences of vehicles

Economy
- Relative growth and composition of the state economy
- State budget surplus versus debt
- Ability to attract and retain business/industry
- Tension versus cooperation between business and the environment, in particular climate change
- Strength of private sector industry in influencing policy

Investment and Infrastructure
- Conditions and source of investment finance
- Level of interest in energy infrastructure improvements
- Focus of attention – electricity grid, power generation, natural gas distribution, transportation fuels or technologies, etc.
- Incremental improvements versus radical changes
- Technology, and policy innovation in infrastructure
- Role of private and public sectors in ownership, maintenance, management

Technology
- Design criteria – cost, service, de-carbonization, efficiency, convenience, air quality
- Focus on incremental versus fundamental change pathway
- Target of technology support – R&D, demonstration projects, market pull/push, institutional innovation
- Motivation for developing Hydrogen fueled energy system

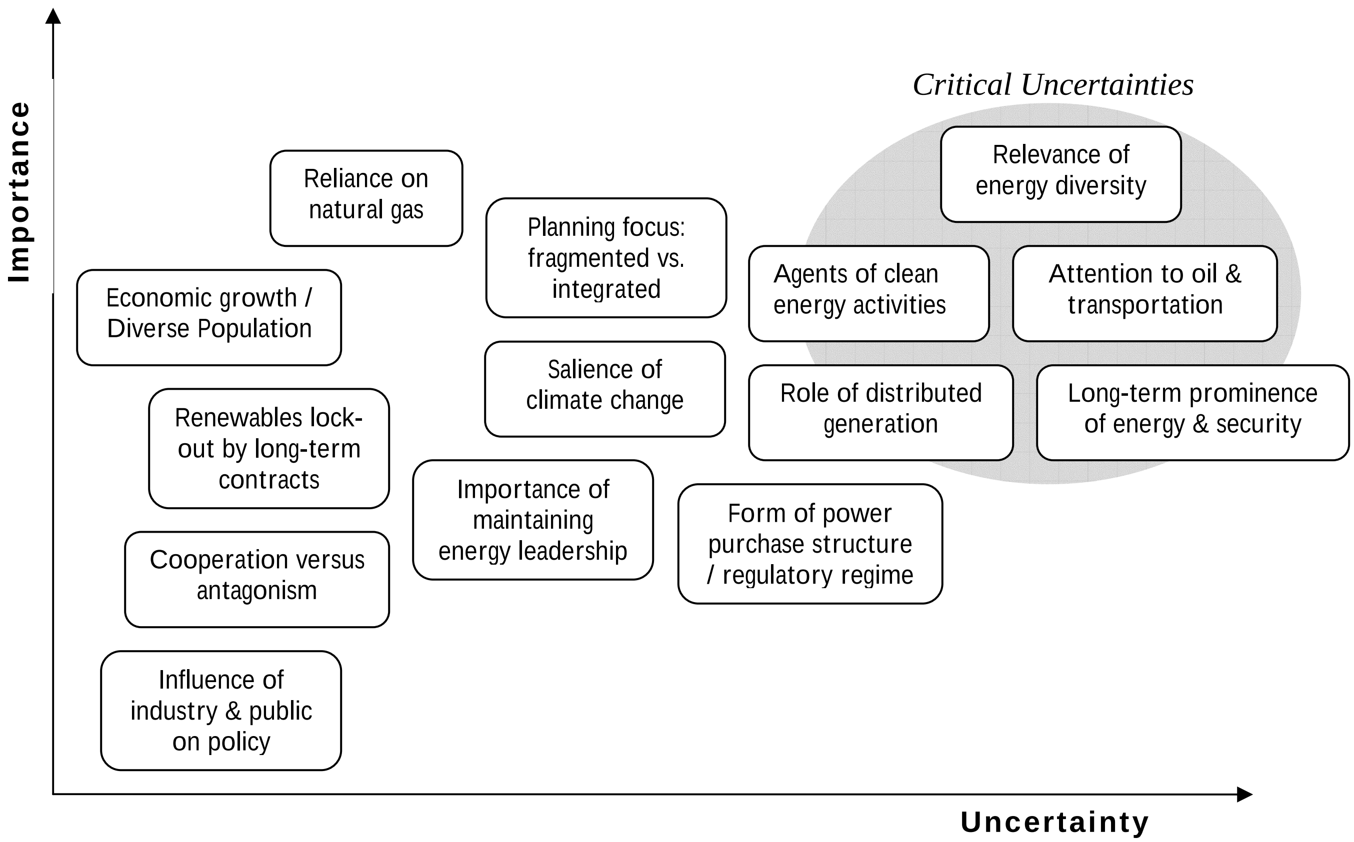
Opportunities/Barriers
- Viability of renewable energy and energy efficiency
- Level of support for "clean" energy technologies – electricity generation and transportation
- Facility of interconnection for distributed generation
- Innovation in energy service provision
- Market "lock out" by long-term contracts
- Development of real-time pricing instruments and services
- Potency of state and federal transportation policies

Fuel and energy resources
- Fuel price volatility versus stability
- Natural gas and/or oil supply constraints
- Electricity cost recuperation of long-term contracts
- Relative cost of alternative technologies
- Greater reliance on natural gas
- Dominance of petroleum/transportation energy demand

2.4 Step Three: Evaluating Forces by Importance and Uncertainty

In elaborating the list of important factors and establishing broader categories, it becomes apparent that certain critical factors thread between the list of elements. These unifying topics can be called driving forces. They represent central points of interconnection between other forces and are particularly important in thinking about critical sites of change in energy systems. This analysis identifies fourteen key driving forces, which are presented within the rounded rectangles in the figure below. Evaluating the relative importance and uncertainty of each driving force, certain elements emerge as both highly important and uncertain. These driving forces can be considered critical uncertainties. They are the factors in California's energy system with the greatest potential to motivate fundamental changes and deviations from current trends.

Figure 2.1 Evaluating Critical Uncertainties

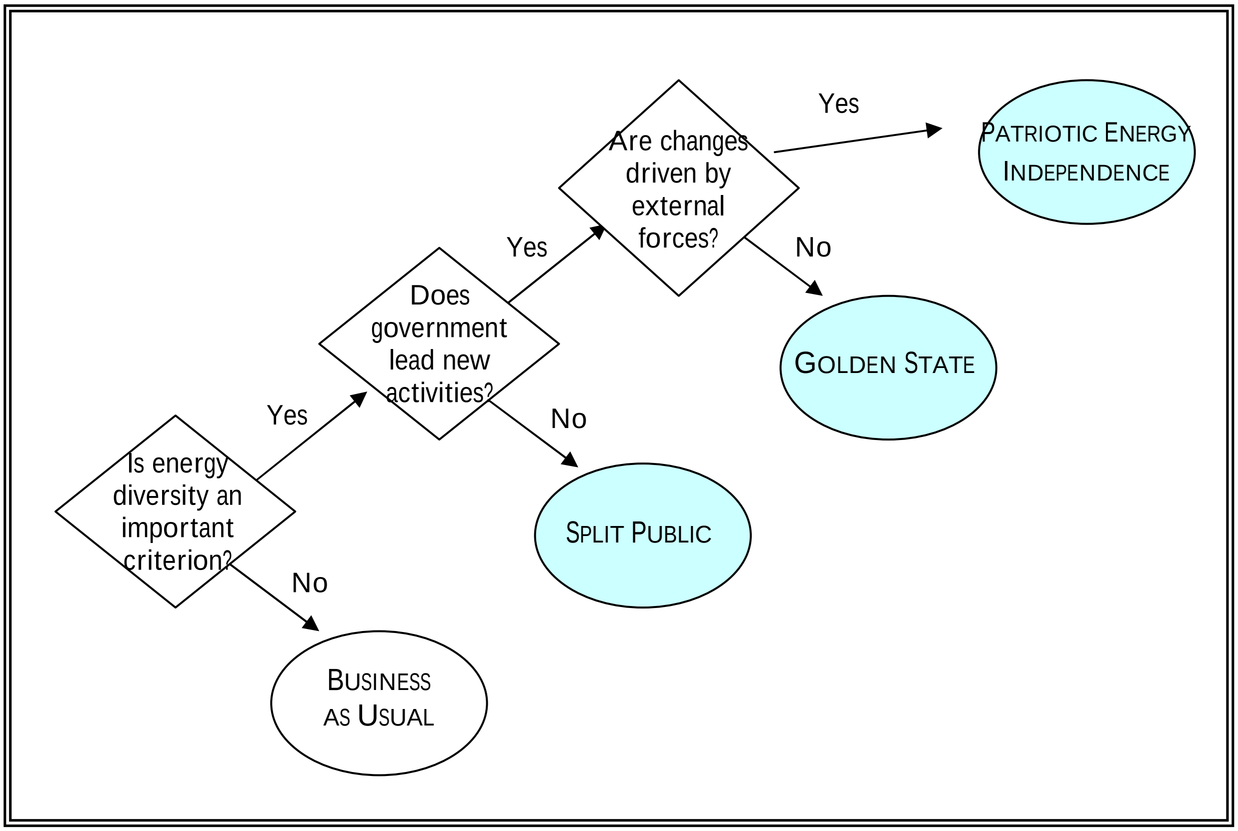


The importance of energy diversity in the state is perhaps the most important and uncertain driving force to the focal issue of clean energy pathways. Energy diversity is a concept with numerous interpretations and uses. It usually implies diversification beyond fossil fuels to incorporate a greater fraction of renewable energy sources. However it may also be linked to development of nuclear energy or un-exploited fossil fuels. Energy diversity is a concept invoked by a range of different interests including air quality, climate change, fuel prices, resource dependence, and supply security. How this concept is interpreted and to what extent it becomes an important criteria will have a significant impact on the priorities driving energy decision-making and activities in the state. Two other critical uncertainties are linked to oil and transportation. Petroleum fuels for transportation represent the largest component of energy demand in California and in the U.S. The majority of this oil is imported from abroad. To what extent decreasing oil consumption and transportation impacts become driving forces is fundamentally important to California's energy system. The prominence of international energy and security linkages is also fundamental to emerging energy pathways. Arguably the most profound changes in California and U.S. energy pathways emerged following the world oil crisis of the early 1970's. Availability of inexpensive oil supply depends in large part on a cooperative international world order. Fragmentation and emerging crises could have a huge impact on energy pathways not only in California but also in the rest of the world. An equally critical uncertainty in considering the focal issue of clean energy is who will be the agent of such activities. With the current context of regulatory and organization uncertainty in California's electricity sector, it is unclear whether the public, government, or the private sector would provide this leadership. Linked to this question of agency is the role that distributed generation will play in the state. Historically the state and private companies were responsible for the development of renewable energy and other distributed resources. However, state led activity in distributed generation is less clear in the future. At the same time, individual and community activities in distributed generation are increasing. What role distributed generation and renewable energy take in the state is a key dimension of considering how clean energy may be incorporated into future energy pathways. These five critical uncertainties are the critical dimension around which the three alternative scenarios are formed.

2.5 Step Four: Selecting the Scenario Logic

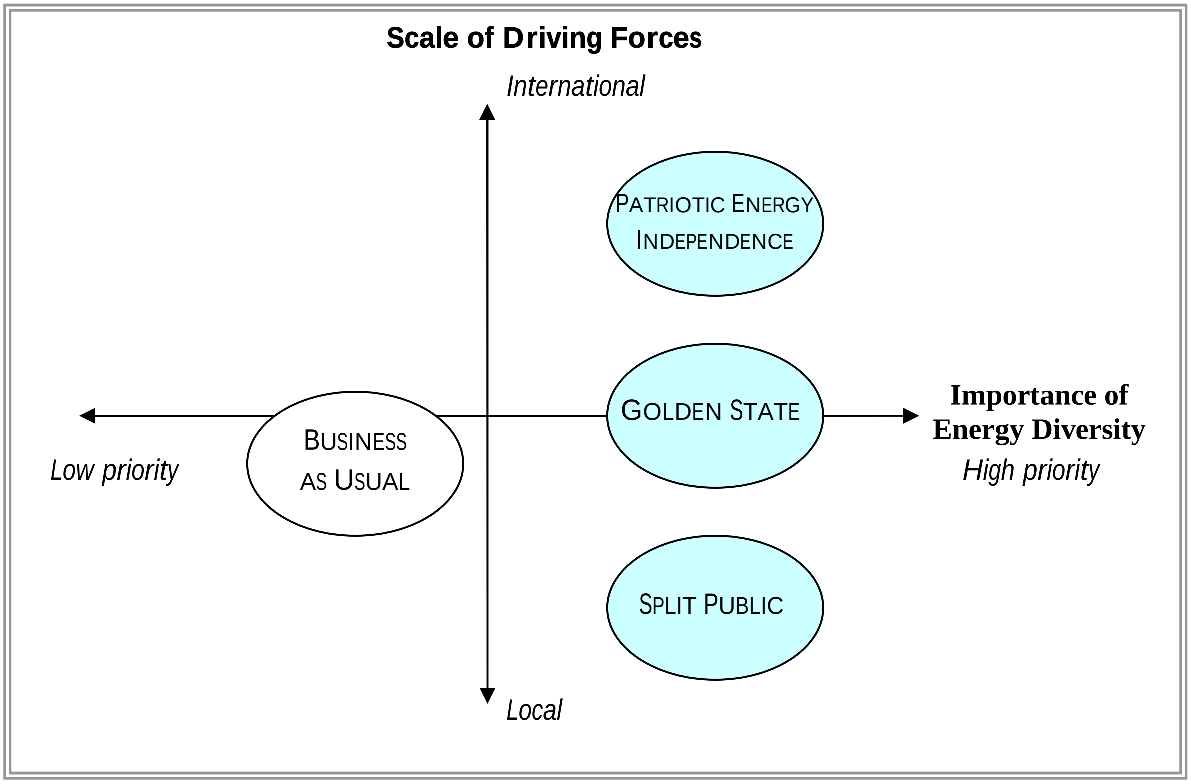
The simple logic used to develop the three alternative energy scenarios is presented in the figure below. The key branch points in California's energy pathway are based around three basic questions involving energy diversity, government involvement, and scale. The first branch point depends on whether energy diversity becomes a more important criterion. A "no" answer yields a world where business-as-usual expectations about the future materialize. The three alternative scenarios portray worlds where energy diversity gains prominence. The second branch point is driven by the question of whether government plays a prominent role in leading new clean energy activities. A "no" answer to this question generates the first alternative scenario called "Split Public". In this scenario, clean energy activities are led by a new active segment of the public. The other two alternative scenarios involve government activity, but are separated by the question of whether changes are driven by forces external to the state. "Golden State" reflects a future where integrated state energy planning leads to a new era of energy leadership and cooperation. "Patriotic Energy Independence" arises from a fragmented international world order which evokes radical changes to the U.S. energy pathway.

Figure 2.2. Branch Points in California's Energy Pathway



The three alternative scenarios, "Split Public", "Golden State" and "Patriotic Energy Independence" all represent worlds where clean energy plays a greater role in California's energy system. The two-dimensional matrix below shows the common feature of the alternative scenarios in increasing the prominence of energy diversity compared to business-as-usual expectations. The three alternative scenarios are fundamentally different in the scale of the forces driving changes from the BAU pathway. "Split Public" is driven by local activities; "Golden State" gives importance to integrated state planning; "Patriotic Energy Independence" is driven by the national response to international conditions. In this way, each of the scenarios explores an alternative pathway for increasing energy diversity.

Figure 2.3. Developing Scenarios Around Critical Uncertainties



Underpinned by different scales of driving forces, each scenario represents an alternative way that the five driving forces specified in the previous section may interact to create different sets conditions under which energy diversity is incorporated into California's energy pathway. Together these three scenarios explore the trade-offs and forms of different potential clean energy activities.

2.6 Step Five: Develop Stories around Critical Uncertainties

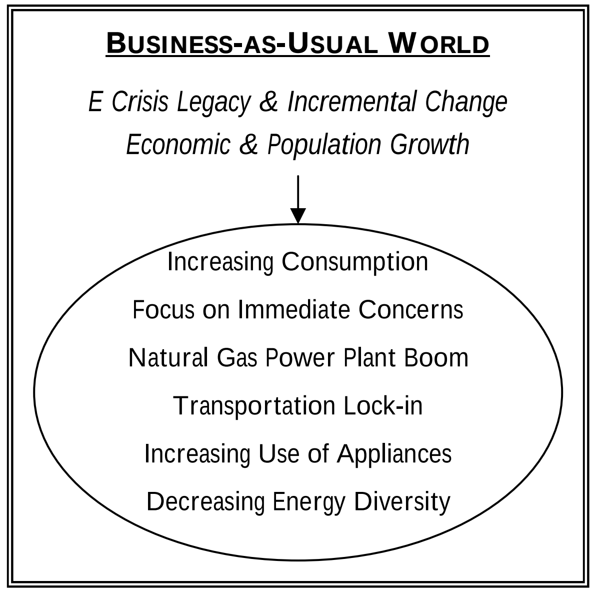
Weaving narratives around each of these scenarios creates a set of interesting and different stories about how the future may unfold. Each story pushes and probes at different dimension of the unifying focal issue. The base case scenario, "Business as usual", develops a coherent and plausible story around the patterns presented in state and federal forecasts and current expectations about the future. The three alternative scenarios, Split Public, Golden State, and Patriotic Energy Independence tell stories about different ways that energy diversity and clean energy technologies may play a greater role in future energy systems. None of these stories provides an ideal outcome or realization of the full potential of clean energy. Instead they explore different mixed-word contexts in which new priorities may emerge. These stories are an interesting starting point for thinking about alternative future pathways and expanding the universe of exploration beyond business-as-usual forecasts.

Table 2.2. Dimensions of the California Energy Scenarios

	BUSINESS AS USUAL (BAU)	SPLIT PUBLIC	GOLDEN STATE	PATRIOTIC ENERGY
SOCIETY	*Post-deregulation world functions without integrated logic*	*BAU frustrated consumers and communities champion "clean" energy*	*Integrated planning slowly emerges from earlier crisis*	*New international order inspires patriotic energy independence*
AGENT OF CHANGES	Fragmented activities, energy crisis legacy	Enviro-consumer public, local governments	State, public, private sector cooperation	International fragmentation, National security, Reinterpretation of American lifestyle,
IMPORTANT ACTORS	Governor, legislature, FERC, natural gas power generators, suppliers, and pipeline companies	Polarized public of "Enviro-consumers" & "BAU big-car buyers", Power sector lobby	Active public, community groups, state government, facilitators of integrated planning, private sector	President, public, automakers, international technology transfer alliances: Japan & Germany
POLICY AND TECHNOLOGY INSTRUMENTS	Long-term contracts	Consumer behavior, local organizing, city policy, propositions, initiatives	System planning, state clean energy policy, dialogue & consensus building	National policy, Research, development & commercialization, Strategic partnerships
ELECTRICITY GENERATION	- New natural gas plants - High electricity prices - DG growth hindered by market lock-out - Modest support of new renewables - Solar buy-downs popular though marginal overall - Major changes unrealized	- Take-off of residential solar market - City renewable energy initiatives - Public pressures on utilities and state government - State and national power struggles over energy authority	- Active state policy encouraging renewable energy - Concurrent local activity in clean energy - New players step in to provide energy services for a DG-centralized mixed world - CA becomes exporter of renewable technologies - Decreasing reliance on natural gas	- U.S. focus on clean coal, exploitation of domestic fossil reserves, ANWAR opened and used quickly - near term environmental backtracking, long-term commitment to decreasing fuel dependence - Solar home systems become modern "victory gardens" - U.S. builds alliances with Germany & Japan in effort to quickly develop renewables
TRANSPORTATION	- Existing policies - Modest personal hybrid & electric vehicles use - Overall transportation preferences unchanged	- Enviro-consumers boost hybrid & electric sales - Enviro-communities use alternative transit fuels - Market pull insufficient to accelerate hydrogen technologies	- Aggressive state commitments to alternative vehicle fleets - Hydrogen transportation remains undeveloped	- Hydrogen transportation becomes U.S. priority - Massive expenditure on fuel cell commercialization - Japan-U.S. exchange: fuel cell vehicles for natural gas - Conspicuous fuel consumption is unpatriotic
ADDITIONAL DEMAND	- Increasing residential, commercial, and industrial demand from consumption and technology penetrations	- Increases in technologies - solar energy generation, solar water heating, energy efficiency by enviro-consumers	- State re-interest in energy efficiency - Blurring of supply and demand boundaries	-Energy efficiency becomes political buzzword - DG enhances reductions
MOTTO	*"Same old thing"*	*"Energy Pioneers"*	*"Reclaiming leadership"*	*"United we stand"*

2.6.1 The Base Case Scenario - Business-as-usual:

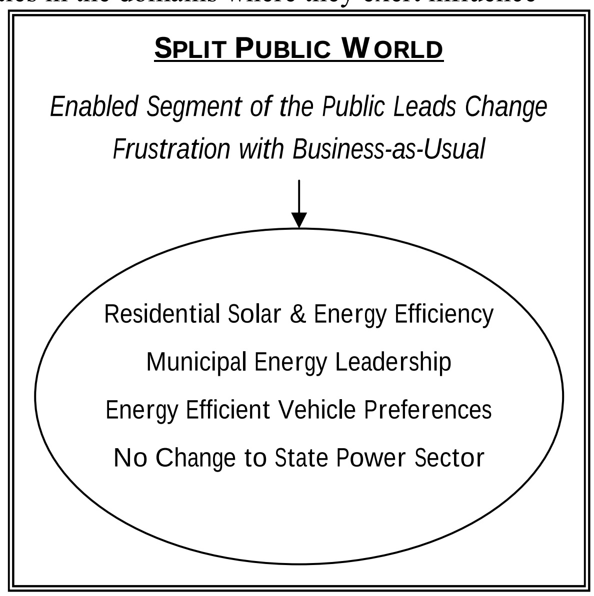
In the context of post-deregulation uncertainty, the future California maintains a sort of limbo between semi-state control and semi-market system which develops neither an integrated logic nor a unified vision for the future. Working without a clear regulatory framework and in an environment of intra-agency and intra-branch power struggles, state government focuses its disjointed bureaucracy on immediate concerns. The private sector follows through on construction of most of the natural gas power plants approved during and immediately following the "Energy Crisis". The first decade of the new millennium is reminiscent of the 1950's generation construction boom, only this time combined cycle natural gas power plants rule the day. The state renegotiates some modest changes to the terms of the long-electricity term contacts coming out of the energy crisis. However, much of the composition electricity generation over the next ten years is defined by a handful of electricity contracts. Benefiting from these long-term contracts, a small group of energy companies gain substantial financial returns. Renewable energy generators are hindered by the reduced market size that is available after long-term contracts are met as well as the incoherent market structure. Many fold or seek business in more active renewable energy regions like the Pacific Northwest and the Midwest where significant renewable energy activities begin to take hold. Small numbers of state-run renewables projects maintain capacity levels similar to historic levels, but with massive new construction of natural gas plants, energy diversity is drastically decreased. Consumers feel they gained neither better service nor cleaner energy for the higher prices they pay. However, in general consumers pay little attention to energy now that it is no longer in the media spotlight. The general opinion is that the energy system "is as it as always been" and consumers have little personal connection to energy choices and outcomes. Public opinion on transportation remains equally locked-in. Big luxury cars and SUV's continue to gain market share, and people generally feel entitled to consume what they can afford. A small group of consumers and communities pursue distributed generation and alternative transportation technologies on their own, financed by their own interest in the environment and supplemented by state buy down programs when they are available. Overall, the general public expresses the attitude, "let's pick up where we left off before the crisis". The state economy grows steadily larger at a rate slower than in the late 1990's, but steady enough for consumers to increase the size of their homes, buy new cars, drive more, use bigger and better appliances and technologies. The state's earlier image as a leader of progressive energy technology and policy begins to fade. A handful of cities and individuals forge ahead with clean energy activities, mainly focused on solar and alternative transportation technologies. However, without cooperation major changes are unrealized.



2.6.2 Alternative Scenario 1 - Split Public

Split Public is a world of sharp contrasts – the preferences and activities of an enabled segment of the public diverge from the status-quo. Contesting the business-as-usual approach of the world around them, a segment of the public organizes around alternative priorities and activities. Split Public highlights a new agent of energy leadership. It also reflects uneven processes and priorities within California's energy and development pathway.

Split Public is an increasingly polarized world. Rallying around calls for individual and community leadership, "enviro-consumers" promote clean energy activities in the domains where they exert influence and control – in households, consumer preferences, and communities. The instruments of aggressive local change are consumer buying power and community organizing. Alternative vehicles, solar water heaters, energy efficient lights, and community solar projects dominate in "enviro-households" and "enviro-communities". However, as one segment of the public champions a new vision of the future, a conservative counter force becomes even stronger within the remaining public who prefer business-as-usual worlds. As "enviro-consumers" become more vocal in contesting the so-called "big-car" way of life, Split Public society becomes more rigid, reinforcing the newly framed dualistic roles.



In Split Public, state government finds itself pulled in opposite directions by "enviro-consumers" on the one hand and "big-car" drivers and the private industry, particularly the power sector, on the other. Itself fragmented and struggling to clarify its authority and direction, the state is an ineffective mediator to conflicting interests. Without state leaderships, new activities are confined to local and individual action.

Municipal governments become active sites of new activities. Frustrated by state inaction, the segment of the public interested in energy alternatives turns its attention to municipal government where their efforts for new energy policy are more successful. A flurry of municipal energy propositions – many focused on renewable generation and technology purchase programs – emerge across the state. San Francisco becomes the leading city in the country for municipal, commercial, and residential solar and wind energy generation – an ironic honor, given its other claim to fame as the "foggy city". Municipalities become the key arenas of organizing climate change mitigation policies. Numerous communities make and exceed carbon dioxide emissions reductions commitments. Simultaneously, as municipal governments become more involved in energy, a greater tension develops between municipalities and utilities and state government who see municipal activities as both demanding and threatening to their authority.

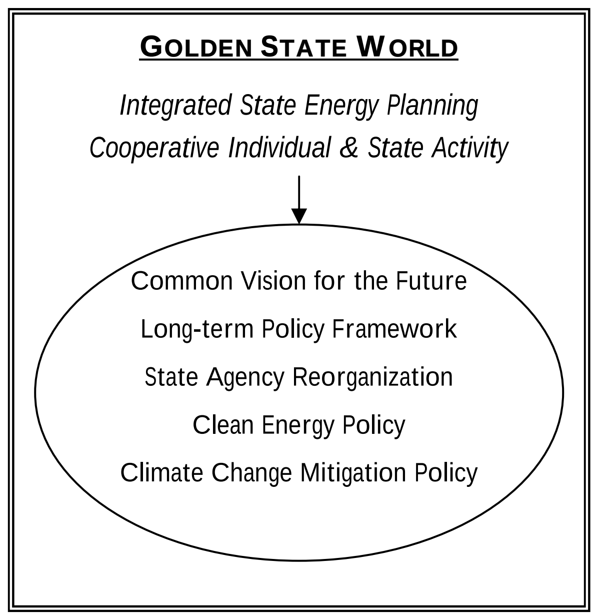
Split Public is a world where contrasting visions about the future play out in the state's energy pathway. It explores the implications of aggressive clean energy activities by a single segment of society on the local scale. Split Public is a world of counter-forces. Hybrid and electric vehicles drive alongside SUV's and luxury cars. Households cut demand for centralized power through energy efficiency and solar electricity generation while construction of larger, well-lawned homes in hotter and drier areas simultaneously blossoms. Enviro-communities with alternative fuel buses and solar initiatives border on communities where "My SUV and proud of it" bumper stickers don many a vehicle. Simultaneously incremental and aggressive, Split Public explores the uneven forces underlying one possible energy pathway.

2.6.3 Alternative Scenario 2 – Golden State

Rallying around California's historic sense of pride in progressive energy technology and policy, earlier fragmentation and crisis give way to a new era of cooperation and integrated resource planning. The Golden State explores the implications of coordinated state and local level activity in clean energy. Golden State learns from the past and explores new cooperative arrangements.

The lessons learned from the Electricity Crisis become significant driving forces for new visions about the future. Stakeholders come to share the belief that cooperation has the potential to achieve higher gains for all participants. The earlier approach of exclusive maximization of individual gain during deregulation led to massive liabilities and uncertainties which harmed all stakeholders – consumers, generators, politicians, investors, and utilities. Even private generators who originally reaped the benefits of the Energy Crisis, found their success short-lived. The collapse of a prominent energy company and the subsequent devastating loss of investor confidence in the electricity sector created the conditions where cooperation could take root.

In Golden State, active state leadership emerges as a key driving force of energy pathways. In the early part of the 21st century, the state spearheads development of a comprehensive energy policy framework for the future. Working with stakeholders over a number of years, these activities generate a central vision for the future and provide a reference point for state decision-making. Coming out of this process, the state undergoes a significant reorganization of agency structure – both consolidating and integrating authority for energy planning, review, and policy.



Activity around climate change mitigation and clean energy become central features of the state's long term energy plan. An aggressive renewable portfolio standard is the central policy instrument for developing viable and competitive renewable energy markets. Consumers and communities pursue solar energy alternatives on a local scale. The overall adoption rates of renewable energy and alternative transportation technologies on the household level are lower than in Split Public, however this scenario leads to a potentially stronger foundation for activities over the long-term. New models for private sector energy companies emerge to provide for the range of new services demanded by using a more diverse energy portfolio. The state also leads the nation in setting carbon dioxide emissions reductions commitments. Mitigation activities are funded through a state carbon tax which is viewed as the most effective and efficient mechanism for achieving emissions goals.

Golden State changes occur less quickly than in Split Public. Integrated efforts are inherently slower to develop. Consensus building and visioning take time and significant institutional effort to materialize. As well, state and local clean energy priorities are not able to provide sufficient market-pull or push to develop hydrogen based transportation technologies. Golden state is a coordinated world, it makes a leap forward in terms of progressive energy policy and participation. At the same time, it also incremental in terms of transportation policy.

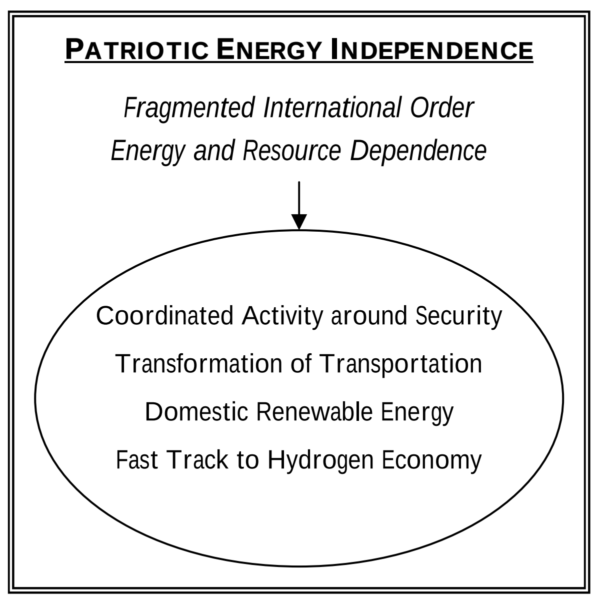
2.6.4 Alternative Scenario 3 – Patriotic Energy Independence:

Patriotic Energy Independence is a world driven by external forces. A new international order emerges as resource and population rich countries struggle to achieve what they perceive is their rightful position in the world economy. International labor, energy, and resources become key instruments of influence by what was once called the third world over the technology and economically rich countries. Patriotic Energy Independence is a time characterized by international social unrest, political upheaval, and militant counter-movements. Fragmentation and power struggles emerge as the new international status-quo.

Facing an increasingly chaotic and hostile world, the U.S. actively defends "its piece of the international pie". Seeing the world as "us against them", Washington becomes increasingly convinced it will have to "go it alone" and focus development within the boundaries where it can exert control. Patriotic Energy is simultaneously an international and a nationalistic scenario. The U.S. attempts to create a fortressed economic and political suborder among the previous OECD countries. Developing strategic alliances along economic, technological, and resource lines becomes the key foreign policy challenge of the new era.

Threatening the viability of an independent and isolated sub-order is the U.S. dependence on foreign oil. The West is no longer able to assume the availability of a continuous flow of cheap oil. Significant effort is made through foreign policy negotiations to insure oil supply. However, with numerous forces converging to threaten the political and economic hegemony of the U.S., its foreign policy leverage struggles to maintain its power over its once oil producing allies. Recognizing newly found leverage, oil producing countries begin exerting conditions to oil sales and contracts which threaten to reverse the international terms of trade of the previous economic order.

In this changing world, decreasing oil dependence becomes central to national security. National policy and national patriotism create a powerful energy independence movement within the U.S. This new national vision creates a complete reframing of energy, resources, and the environment. Immediately the U.S. focuses on the development of domestic energy resources - national coal, oil, and natural gas are exploited with the best available technologies. Oil reserves in Alaska are quickly exploited as the nation begins to transition to other fuels. Coal becomes the strategic security resource, seen as the instrument of transition to a hydrogen economy. Coal is used directly, but also as a means of producing natural gas and hydrogen.



Development of a hydrogen economy becomes a unifying national vision for the future. Massive government spending is directed at development of an oil-free transportation system. The President calls upon the U.S. public to embrace the "New American Way" and buy new low-oil consuming cars – first electric and hybrid vehicles and later fuel cells. The government provides large consumer transportation purchase subsidies. New car buying is seen as essential to growth of the new-isolated American economy, to reduction of oil consumption, and to infusion of capital into the auto industry. Renewable technologies are seen as part of the pathway to the future – necessary both to generate electricity and hydrogen. Natural gas is reserved for high value uses such as heating and electricity load balancing with renewables.   The U.S. scrambles to build alliances with Japan, Germany and Denmark to accelerate development of viable transportation and renewable energy technologies and markets. Washington and Tokyo negotiate a technology transfer arrangement exchanging fuel cell vehicle research and production know-how for long-term natural gas contracts. This assistance accelerates Detroit's ability to transition to fuel cell vehicle production. Similar arrangements with Germany and Denmark occur to increase U.S. capacity to produce solar and wind technologies.

Patriotic Energy Independence reflects conditions which radically reframe the American way of life. Solar home systems become the "victory gardens" of the new world order. SUV's become unpatriotic. Smart cars, hybrids, electric, and later fuel cell vehicles dominate the roads. This transition takes time, but the pathway is profound and aggressively pursued. A new international world inspired a new pathway.

Section 3. Developing the Model & Examining the Results

Models and stories provide complementary information to scenario analysis. According to Gallopin and Raskin (1998), narratives provide "texture, richness, and insight" while models offer a level of "structure, discipline, and rigor to the analyses of socioeconomic, resource, and environmental conditions". In the context of energy scenarios, energy system modeling grounds scenarios within the reality of the existing energy structure and characterizes the physical dynamics of different energy pathways. Energy system modeling adds plausibility and coherence to interesting stories. This research integrates stories and models to explore alternative energy pathways for California in a way that highlights choices and value dimensions while maintaining consistency with physical dynamics of energy systems.

This section is the analytical complement to the qualitative scenarios. Here, a set of scenario modeling methods and results are presented which elaborate the energy and fuel implications of the alternative scenarios. This section begins with a brief overview of the modeling methodology and approach. It then turns to the scenario modeling results which form the main focus of this section. Comparing and evaluating scenario results highlights sensitivities, opportunities, and trade-offs. Business-as-usual modeling results provide a reference case that reflects current expectations about the future. The alternative scenario results show how different assumptions about the future lead to different outcomes. Comparative analysis of the alternative scenarios leads to the concluding discussion of the implications of the energy scenarios for California.

3.1 The California Energy Scenario Model

This project uses an accounting and scenario based modeling platform called Long Range Energy Alternative Planning System (LEAP2000[3]) to create a multi-sector model of energy supply and demand in California. The California LEAP framework is an end-use model which characterizes energy and fuel use as well as greenhouse gas emissions characteristics of each scenario between 2000 and 2020.

Assembling the California Energy Dataset - In order to build the model and develop the scenarios, it was first necessary to assemble an extensive energy dataset of historic and forecast data for California. As there is no single source for state-level energy data, organizing the data set was an extensive task. The data set draws on information from a large number of state and national agencies as well as research reports from government laboratories and research organizations. The most substantial data sources are presented in the table below. A detailed list of energy data sources from this analysis is organized by individual sectors in the bibliography.

Table 3.1 Important Data Sources for the California Energy Dataset

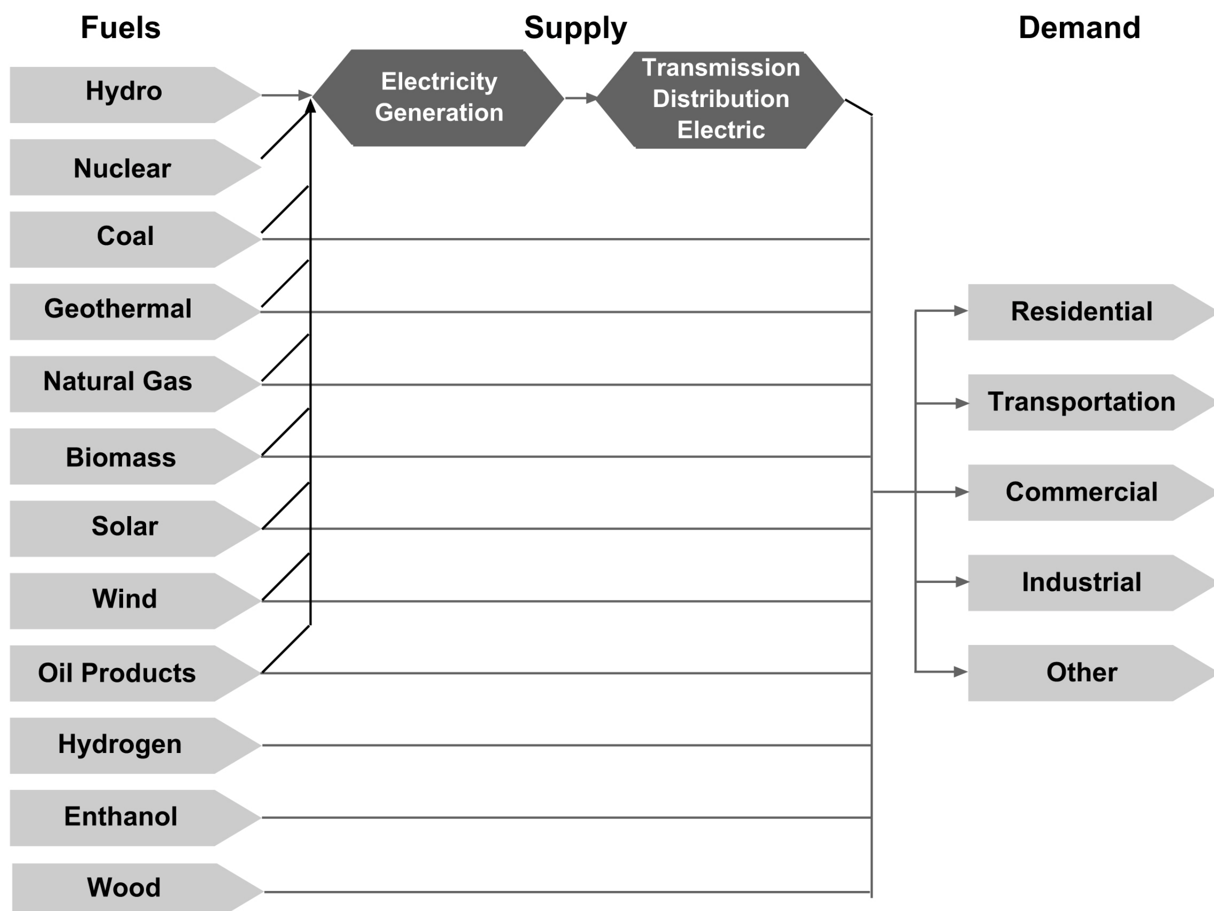
Sectors	Key Sources
RESIDENTIAL	Statewide Residential Lighting and Appliance Saturation Study (RLW Analytics, 2000) U.S. & State Residential Energy Consumption Surveys 1993/97 (U.S. DOE, 1995, 1999a) PG&E Residential Energy Survey Report (PG&E, 1994) Energy Sourcebook for U.S. Residential Sector (LBNL Report: Wenzel, et al., 1997)
TRANSPORTATION	California Air Resource Board, Emissions Factor 2000 Model Outputs (CARB, 2001) California Motor Vehicle Stock, Travel and Fuel Forecast (CalTrans, 2000) California Energy Outlook 2000, Transportation Energy Systems (CEC, 2000b) National Transportation Statistics 2000 (U.S. DOT, 2001)
COMMERCIAL	Commercial Electricity & Natural Gas Consumption Forecasts 2002-2012 (CEC, 2001d)

[3] LEAP 2000, the Long-Range Energy Alternative Planning System is an accounting and scenario-based energy-modeling platform developed by Stockholm Environmental Institute in Boston. More information is available at the SEI-Boston website, http://www.seib.org/leap

INDUSTRIAL	Industrial Electricity & Natural Gas Consumption Forecast 2002-2012 (CEC, 2001e)
ELECTRICITY GENERATION	California Electricity Outlook Report 2002-2012 (CEC, 2002a) Emissions and Generation Resource Integrated Database (EPA, 2001) Database of California Power Plants 1998-2001 (CEC, 2001g) Inventory of Utility & Non-Utility Power Plants in the U.S. 1999 (U.S. DOE, 2000e/f)
FUEL BALANCE	State Energy Data Report 1999 (U.S. DOE, 2001a)

Organizing the Model Structure – The California energy scenario model organizes California's energy system into five demand sectors: residential, transportation, commercial, industrial, and other, and one fuel transformation sector: electricity generation. Fuels are used either to generate electricity or to directly serve demand. Within the model, electricity and fuel requirements of the demand sectors drive the level of overall electricity generation and fuel use. The basic model structure is presented schematically below.

Figure 3.1 The California Energy Scenarios Model Diagram



Supply and Demand Sectors - Each individual supply and demand sector is disaggregated into end-uses and technologies which consume, generate, or transform fuels. The structure of each sector accommodates policies and changes associated with the scenarios and are directed at specific technologies and end-uses. The model structure also depended on the type of state-level data available for each sector. Technologies and/or end uses are characterized by a set of specific parameters, including: market saturation, fuel consumption, energy efficiency, energy intensity, and demographic and/or activity drivers. The detailed structure of the model is presented in the following table.

Table 3.2 Organization of the California Energy System Model

SECTOR	SUB-CATEGORIES	ACTIVITY PARAMETERS	DISAGGREGATION	PARAMETERS	FUELS
Residential	Space Heating Air Conditioning Water Heating Refrigeration Lighting Appliances	Households (# hh) Saturations of End Uses (%)	End Use Technologies	Saturations (%) Unit Energy Consumption (E/yr)	Electricity Natural Gas Wood LPG Kerosene Fuel Oil
Transportation	Passenger Freight Air	Population (# pp) Passenger Miles Traveled (PMT) Freight Miles Traveled (TMT) Air Miles Traveled (VMT)	Cars Motorcycles Light duty trucks/SUVs Buses Amtrak Other Transit Freight Trucks Rail Freight Water Freight	Share of PMT (%) Fuel Economy (E/PMT, TMT, or VMT) 7 Technology Types: Gasoline Diesel Hybrid-Gasoline Hybrid-Diesel Electric CNG Fuel Cell	Gasoline Jet Fuel Diesel Residual Fuel Oil Aviation Gasoline Lubricants LPG Electricity Natural Gas Ethanol
Commercial	11 Building Types (ex. Food Stores)	Floorspace (ft^2) Shares of Floorspace (%)	9 End Uses	Saturations (%) Fuel Energy Intensities (E/ft^2 * yr)	Electricity Natural Gas Petroleum Wood & Waste Coal
Industrial	31 Sub-sectors (ex. Printing and Publishing)	Value of Shipments ($) Shares of Value of Shipment (%) Fuel Energy Intensities (E/$ * yr)			Electricity Natural Gas Petroleum Coal Wood & Waste
Agriculture Streetlights Transportation, Communication, and Utilities		Gross State Product ($) Population (# pp) Gross State Product ($) Fuel Energy Intensities (E/$ or person *yr)			Electricity Natural Gas
Electricity Generation	18 Technology Types (ex. Natural gas steam turbine)	System Load Curve Capacity (MW) Base year Output Maximum Capacity Factor Efficiency (%) Fuel Shares (%) Merit Order (1st - 5th) Planning Reserve Margin (%)			Natural Gas Oil Coal Nuclear Hydro Biomass Geothermal Wind Solar
Electricity Transmission & Distribution		Losses (%)			

Constructing Base Year - The California scenario model characterizes the structure of the state's energy supply and demand system for each year between 2000 and 2020 using the organizational structure outlined above. The first year of the model, or base year, was developed from existing state-level data. Each of the scenarios begins in 2000. The base year is consistent with both top down (overall fuel balance) and bottom up (technology and end uses) estimates of the magnitude and composition of energy and fuel consumption.

Modeling the Scenarios - Scenarios are represented in the energy system model through explicit assumptions of how energy, technology, and activity parameters of the energy system model change over time. The base year provides a common starting point, and each scenario explicitly determines how the composition and attributes of energy supply and demand structure will change over time. The Business-as-usual scenario is based on sector and fuel forecast data from state agencies, most notably the California Energy Commission. The BAU reflects "official" expectations for the future based on current trends. The BAU scenario serves as a reference scenario and point of comparison for the alternative scenarios.

The alternative scenarios are based around sets of plausible policies, choices, and patterns that emerge from the context of each scenario story. These elements are represented in the model through sets of assumptions of how energy, technology, and activity parameters change over time. In this way the model links narrative to specific physical changes in use patterns, technology attributes, or demographic drivers. As a result, the modeling assumptions are robust in three distinct ways:

1) They are consistent with the scenario narratives,
2) They explicitly represent plausible policies and choices,
3) They are integrated into a coherent framework of the state's actual energy system.

Having developed a comprehensive scenario modeling framework, it is relatively simple to explore a wide range of choices, changes, and policies. An illustrative example of linking stories and models together using a simple framework is as follows. In Split Public, an active segment of the population becomes an organized and visible force in California by championing clean energy technologies and practices. One example of their activities is the rapid adoption of hybrid vehicles over the next 20 years by this population. The scenario model represents this dimension of the story within the car sub-category of transportation. The share of vehicle miles traveled by hybrid car technologies is increased from current values to 50% of total car activity by 2020. This example demonstrates how each scenario uses explicit parameter changes to represent specific policies and choices that are consistent with the narratives.

Calculating Energy and Fuel Use - Energy demand and supply for each sector is calculated using a simple set of equations built around technology energy intensities, saturation data, and activity drivers within each sector. Demand and supply are calculated for the sectors in aggregate and at each sub-level using the model structure outlined in Table 3.2. The table below summarizes the generalized equations used to calculate energy supply, demand, and fuel consumption for each year, sector, and scenario.

Table 3.3 General Equations for Calculating Energy Demand and Supply

Energy Demand
Residential = (# hh) x (end use % saturation) x (technology % saturation) x (UEC) Transportation: Passenger = (# pp) x (PMT /p*yr) x (vehicle % PMT share) x (technology % vehicle share) x (fuel use/PMT) Freight = (# pp) x (TMT/p*yr) x (vehicle % TMT share) x (technology % vehicle share) x (fuel use/TMT) Air = (# pp) x (VMT/p*yr) x (fuel use/VMT) Commercial = (Floorspace) x (building type % share of ft^2) x (end use % saturation) x (fuel use/ft^2*yr) Industrial = (Industrial Value of Shipments) x (Sub-sector % share of $) x (fuel use/$*yr)
Notation: #hh - number of households; #pp - number of people; UEC - unit energy consumption (energy consumed by a technology per year); PMT - passenger-miles traveled; TMT - ton-miles traveled; VMT- vehicle miles traveled
Energy Supply
Electricity Generation: Technology capacity, maximum capacity factor, efficiency, and fuel shares; technology categories dispatched to meet annual demand by merit order based on system load curve Transmission and Distribution - Electricity delivered to meet demand based on specified losses

Residential Sector – The residential sector is organized into six end-uses, including: space heating, air conditioning, water heating, refrigeration, lighting, and appliances. Each end-use is made up of different technologies which provide end use services. Energy consumption of a given technology is calculated as the product of the total number of households, the saturation of the end use in residential households, the technology share of the end use, and the unit energy consumption of the given technology. Total energy consumption is the sum of the different technology categories.

For example, in 2000, water heating penetrated 99% of California's 11.5 million households. Natural gas technologies made up 82% of water heater stock in 2000. The average unit energy consumption for water heaters was assumed to be 250 therms per year. The total energy consumed by natural gas water heaters in the state in the year 2000 is therefore calculated to be 2,3000 therms per year ($11.5x10^6$ households * 99% * 82% * 250 therms/waterheater-yr). In the case of natural gas water heaters, each scenario explicitly sets the values for the number of households, saturation of water heating in households, composition of water heating technologies, and the unit energy consumption of each technology between 2000 and 2002. If no changes are specified, the business-as-usual scenario provides the reference values. This same general approach is used for each level of model analysis. Aggregate consumptions are calculated from the sum of consumption of the individual sub-categories.

Transportation Sector - The transportation sector is organized into three large categories. Passenger travel includes cars, light duty trucks, buses, Amtrak, and other forms of transit. Freight travel includes trucks, rail, and water shipping. Air travel includes commercial and private. Each sub-category is comprised of specific technology types, for example gasoline, diesel, electric, and hybrid-electric cars.

Consumption is calculated from the total passenger, freight, and air miles traveled, technology shares of transportation activity, and technology fuel economies.[4]

Commercial, Industrial, and Other Demand Sectors **-** The organization of the commercial, industrial, and other demand sectors reflects the structure of existing data for these sectors provided by the California Energy Commission. The commercials sector is made up of eleven building types and nine end uses. Consumption is calculated from the total commercial floorspace, the share of commercial floorspace of each building type, the saturations of end uses within each building type, and the fuel intensities on a square foot basis for each end use. The industrial sector is made up of 31 industrial sub-sectors. The model calculates consumption from the total industrial value of shipments, sub-sector shares of total industrial value of shipments, and fuel intensities per shipping value for each sub sector. The other demand sector is comprised of agriculture, streetlights, and transportation, communications, and utilities. Similarly, consumption is calculated from the activity parameter and fuel intensities per unit of activity.

Electricity Generation **-** Electricity generation calculations depend on the demand sector calculations. This sector specifies the technology attributes, merit order, and annual system load curve shape of electricity generation sector. Actual electricity generation in any given model year depends on the level of electricity consumption generated by the four demand sectors and the level of imports. The model structure characterizes the generation sector, and then based on the level of electricity required to meet the annual demand requirements, it dispatches technologies to generate the needed electricity.

The power sector in California is modeled using 18 different categories of electricity generation technologies. The technology categories include: steam turbines (natural gas, coal, petroleum coke), combustion turbines (natural gas, oil), combined cycle (natural gas), cogeneration (natural gas), nuclear, conventional hydroelectric, pumped storage hydroelectric, solid waste, landfill gas, digester gas, biomass, solar PV, solar parabolic trough, wind turbines, and geothermal. For each technology type, the capacity, base year output, maximum capacity factor, efficiency, and fuel shares are specified.

Each generation technology category is given a merit order rank (1-5) that determines how technologies are dispatched to meet demand. Based on an input annual system load curve, technologies are dispatched in merit order – ranging from baseload to intermediate to peak load plants. For an illustrative figure of the LEAP method for dispatching processes on a load curve, see the Appendix. This sector also explicitly sets a planning reserve margin and level of transmission and distribution losses. For these analyses the planning reserve margin is 15% and the transmission and distribution losses to 10%.

New capacity additions are added either exogenously or endogenously to the generation sector. Exogenous capacity additions are planned additions with a specific quantity and type of capacity added at a specific time in the future. Endogenous capacity additions are specific technologies that are built as needed to meet the electricity consumption requirements as specified by the demand sectors.

The electricity generation sector modeled in the California scenarios framework is valuable for examining the annual magnitude and composition of power generation. The general simplicity of the dispatch methodology is not suited for examination of instantaneous demand patterns. A more detailed power sector model would be required for this type of analysis. However, the California scenarios electricity

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[4] A passenger mile is an activity parameter specifying the number of miles that people are transported. It is calculated as the product of the total vehicle miles traveled and the number of people per vehicle. A vehicle containing two people that travels 10 miles has traveled 20 passenger miles. Similarly, a freight mile specifies the number of ton-miles. Air miles is simply the number of miles traveled by the airplane. This approach is useful for considering the implications of changes to levels of population or shipping on the transportation sector.

generation sector does offer a simple and transparent framework for exploring both the magnitude and composition of electricity generation over the next twenty years under different scenario assumptions. For far reaching scenario analyses, the LEAP platform is ideal.

Estimating Greenhouse Gas Emissions –

Using the California scenarios framework for energy supply and demand, a set of simple calculations was carried out to estimate greenhouse gas emissions for each scenario. These calculations provide a basis for comparing the potential magnitudes of greenhouse gas emissions for each scenario. They also are a first step toward considering the sensitivities of different activities for climate change mitigation.

The greenhouse gas emissions associated with fuel consumption in California were estimated using average emissions factors for each sector and fuel type, according to Intergovernmental Panel on Climate Change (IPCC) guidelines for national greenhouse gas inventories and 1996 Tier 1 average emissions factors. (IPCC, 1997) The Technology and Environment Database (TED) within the LEAP modeling platform directly links each technology within the supply and demand structure to an average emissions factor based on its sector and fuel use. Total greenhouse gas emissions were calculated in terms of global warming potential in units of carbon dioxide equivalents[5].

The energy system model developed in this project provides a comprehensive and flexible tool for exploring future energy scenarios in California. The model is grounded in the existing structure and composition of the state's energy system. The base year reflects the existing energy system. The Business-as-usual scenario represents current forecast assumptions about the future. The alternative scenarios explore alternative pathways for how the future may unfold. The combined approach of integrating qualitative and quantitative results provides robust framework analyzing energy pathways. Stories provide the contextual and creative backdrop for a set of interesting exploratory modeling exercises. The remainder of this section will present the scenario modeling results.

[5] For more information on the IPCC methodologies for estimation of greenhouse gas emissions, see the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 3: Reference Manual. The report contains environmental data on both supply and demand side energy use and can be read on-line at: http://www.ipcc-nggip.iges.or.jp/public/gl/invs6.htm.

3.2 The Scenario Modeling Results

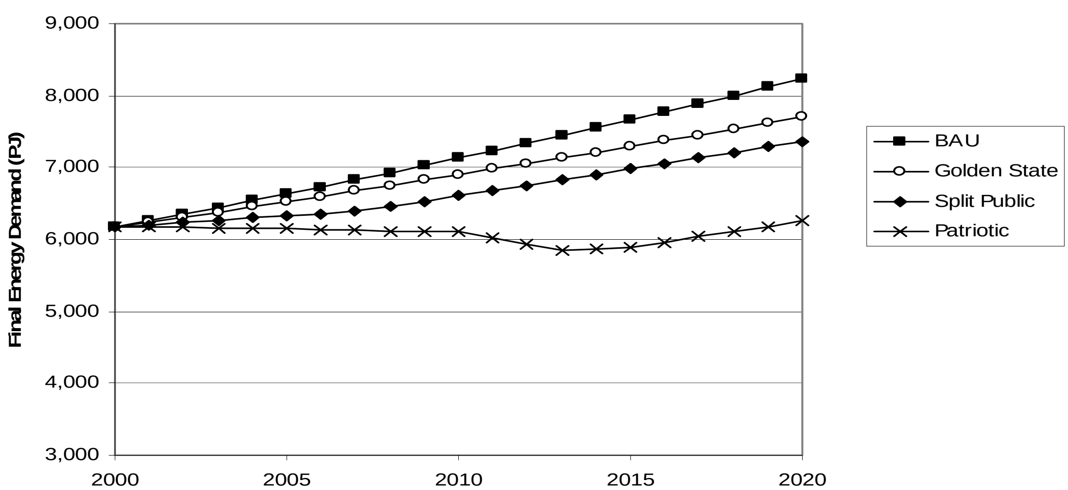
This section presents the scenario modeling results of the Business-as-usual and three alternative energy scenarios - Split Public, Golden State, and Patriotic Energy. It begins first with aggregate energy consumption and then focuses on individual demand and supply sectors in turn. Discussion highlights important features and guiding assumptions for each scenario and each sector. These results also evaluate the overall magnitude and composition of California's primary energy consumption. The concept of energy diversity is presented as a valuable attribute for future energy pathways in the context of California. Using a simple diversity metric, these analyses characterize the composition of energy consumption under each scenario. Lastly, the scenario analyses consider the implications of each scenario for greenhouse gas emissions. Using a simple emissions calculation, based on fuel emissions factors and the final energy balance of each scenario, this section compares the implications of each scenario for greenhouse gas emissions mitigation. Using a range of different metrics, the scenarios provide an interesting set of information about future energy options in California.

The scenario modeling results do not aim to advocate any particular scenario. Rather, they demonstrate a range of possible outcomes which can be critically compared, discussed, and evaluated. These results are a few of the many interactions with future choices and decisions that are plausible and interesting to consider. These analyses represent a starting point for continued discussion and interaction with alternative energy pathways. The paper concludes by presenting a set of critical issues and policy implications for California.

3.3 Combined Energy Consumption of the Demand Sectors

The energy consumption from residential, commercial, industrial, and other demand sectors is expected under Business-as-Usual conditions to increase 33%, or an average of 1.5% per year, over the next twenty years, reaching a level of over 8,000 PJ by 2020. Illustrated below in Figure 3.2, each of the three alternative scenarios achieves significant energy savings relative to BAU. Patriotic Energy reflects the greatest reduction in consumptions relative to BAU – energy consumption in 2020 is equivalent to current levels in 2000. In the other two scenarios, energy savings serve to decrease the rate of increase in consumption from 1.5% per year in BAU to an average of 1.1% and 0.9% per year for Golden State and Split Public, respectively.

Figure 3.2. Combined Energy Consumption of Demand Sectors (PJ)



Note: Petajoules are equivalent to 10^{15} J

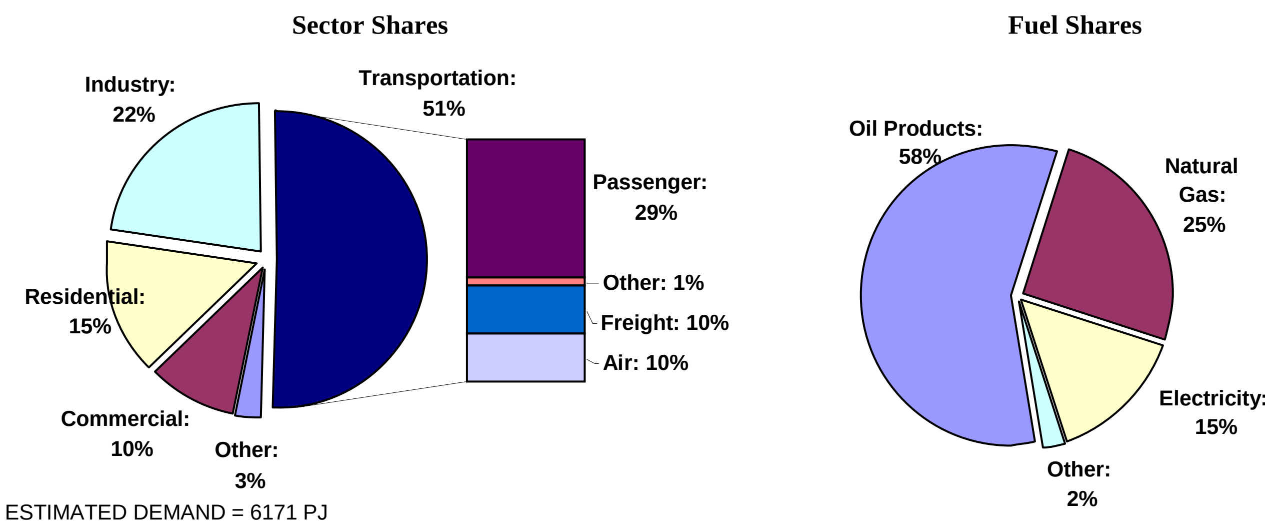
The rate of annual percentage growth is useful for calculations and for plotting each pathway, however the magnitude of actual energy savings is more important to the actual burdens and benefits of each scenario for society. Looking first at the most aggressive scenario, Patriotic Energy, demand in 2020 is reduced by 24% relative to BAU, Split Public by 11% and Golden State by 6%. Over the course of the next twenty years, the Patriotic Energy Pathway saves more than 22,000 PJ of energy. The savings of Split Public and Golden State are also significant, achieving cumulative energy savings of more than 10,000 PJ and 5,100 PJ, respectively. These metrics of comparison are presented in the table below.

Table 3.4. Combined Energy Consumption: Rates of Growth and Relative Savings

		% Reduction vs. BAU		Cumulative Savings
	% Growth / Year	2010	2020	2000-2020
BUSINESS-AS-USUAL	1.5%	-	-	-
SPLIT PUBLIC	0.9%	7%	11%	10,000 PJ
GOLDEN STATE	1.1%	3%	6%	5,1000 PJ
PATRIOTIC ENERGY	0.07%	14%	24%	22,000 PJ

Looking at the composition of combined energy consumption in the figures below shows that base year energy consumption is dominated by transportation which makes up more than half (51%) of total energy consumption. The remaining half of energy consumption is split between industry (22%), residential (15%), commercial (10%), and other demand (3%) sectors. In California, the sector shares correspond in a general sense to particular fuel shares: transportation accounts for most of oil demand and industry, residential, and commercial sectors represent most of natural gas and electricity consumption[6]. The similar sizes of sector and fuel shares in the figures below show this general relationship. In California, oil products dominate energy demand (58%) followed by natural gas (25%) electricity (15%), and other fuels (2%).

Figure 3.3 Composition of Energy Consumption by Sector and Fuel Shares, Base Year 2000



[6] Industry also consumes a measurable fraction of oil, however the general relationship between sectors and fuels is useful overall for considering the composition of energy consumption in California.

Comparing the level of energy consumption within demand sectors further demonstrates the significance of transportation in California's overall energy consumption. Table 3.5 ranks energy consumption of sub-sector categories. Significantly, the top three overall consumption categories are associated with transportation, namely passenger, freight, and air travel. Individually, passenger transportation, which includes travel by personal cars, light duty trucks, motorcycles, buses, passenger trains, and other public transit, is responsible for more energy consumption than either the industrial sector or the residential and commercial sectors combined. Cars and light-duty trucks[7] make up more than 98% of passenger travel. The energy consumption of cars and light duty trucks alone accounts for more than 29% of total consumption. Clearly, all of the demand sectors play an important role in defining the composition of energy consumption and fuel use in California. Transportation has a profound impact and is considered in greater detail in each of the energy scenarios.

Table 3.5 Energy Consumption of Demand Sector Sub-Categories, Base Year 2000 (PJ)

Rank	Sector	Sub-Category	2000	% Share
1	Transportation	Passenger	1,799	29.1%
2	Transportation	Freight	633	10.2%
3	Transportation	Air	611	9.9%
4	Industrial	<Other Fuels> (petroleum, coal, wood/waste)	512	8.3%
5	Residential	Heating	325	5.3%
6	Industrial	Process	317	5.1%
7	Industrial	Mining & Construction	282	4.6%
8	Industrial	Assembly	267	4.3%
9	Residential	Water Heating	265	4.3%
10	Residential	Appliances	185	3.0%
11	Commercial	Large Offices	119	1.9%
12	Commercial	Commercial Miscellaneous	107	1.7%
13	Other	<Other Fuels Aggregate>	104	1.7%
14	Commercial	Agriculture	100	1.6%
15	Commercial	Hospitals	66	1.1%
16	Other	Transportation, Communications, & Utilities	62	1.0%
17	Residential	Lighting	57	0.9%
18	Residential	Refrigeration	49	0.8%
19	Commercial	Food Stores	46	0.7%
20	Commercial	Retail	44	0.7%
21	Commercial	Restaurants	43	0.7%
22	Commercial	Non-refrigerated Warehouses	35	0.6%
23	Commercial	Schools	30	0.5%
24	Commercial	Hotels/ Motels	28	0.5%
25	Commercial	Universities & Colleges	26	0.4%

[7] Light-duty trucks include pick-up trucks, Sport Utility Vehicles (SUVs), and mini-vans under 8,500 lbs.

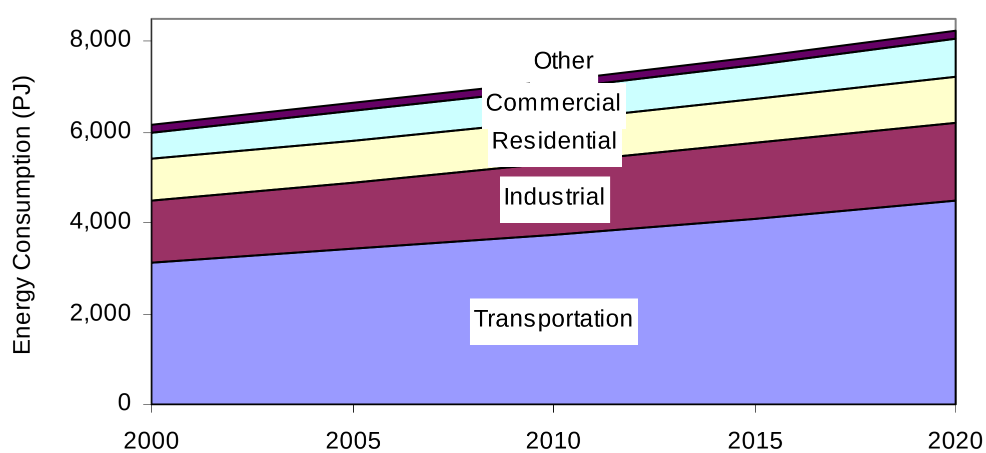
26	Residential	Air Conditioning	25	0.4%
27	Commercial	Small Offices	24	0.4%
28	Other	Streetlights	6	0.1%
29	Commercial	Refrigerated Warehouses	4	0.1%
		Sum	6,171	

Other sub-categories ranked in the top ten include the four industry sub-categories,[8] as well as residential heating, water heating, and appliance end uses. It is important to recognize that the ranking of the sub-categories depends in large part on the way that the scenario model was organized. For example, the commercial sub-sectors rank low on the list, partly because this sector has a high level of disaggregation into different building types. The ranking and its discussion is meant only to facilitate understanding of the composition of energy consumption and demonstrate how activities in certain sectors stand out within a number of different ways of looking at consumption.

3.4 Overview of the Business-as-Usual Scenario

In the Business-as-Usual scenario, energy consumption in all of the demand sectors is expected to steadily increase, with overall demand increasing 1.5% per year on average. Each sector is expected to grow over the next twenty years. Transportation leads expected growth with 1.8% per year, followed by commercial 1.6%, industrial 1.1%, residential 0.5%, and other 0.8%. Notably, the sectors maintain the same relative position in terms of magnitude of consumption over the next twenty years. At the same time, the share of demand associated with the transportation sector increases most significantly in the future.

Figure 3.4 Combined Energy Consumption: Business-as-Usual Scenario (PJ)



The BAU scenario is based on a set of assumptions derived either directly or through interpretation of official state-level forecasts[9]. The most important features of the BAU scenario is an expectation of increases in population growth, steady economic growth (including industrial value of shipments), increasing per capita transportation activity, increasing commercial floorspace, and significant power

[8] Industrial subcategories - process, mining and construction, and assembly - reflect only their electricity and natural gas consumption. Because disaggregated data for other fuels was not available, the category <industrial other fuels> represents aggregate consumption of other fuels based on the energy balance for the industrial sector. This aggregate sub-category is ranked number 4 in Table 3.5.
[9] The bibliography provides a detailed list of data sources used to create the BAU and alternative scenarios.

sector capacity additions. These features are activity drivers which account in large part for the observed scenario results. Additional features that are important to the residential sector include: increasing use of computers and printers, increasing refrigerator sizes, increasing fractions of homes with air conditioning, increasing natural gas efficiencies for heating technologies, and a decrease in the use of wood for heating. The transportation sector changes are driven largely by increases in per capita transportation activities. Transportation technologies remain largely unchanged. Hybrid and electric vehicles achieve only a modest market penetration. Full-gasoline and diesel fuel economy for passenger and freight vehicles remain the same. The energy intensity of air travel is the only transportation technology to achieve fuel efficiency gains in BAU. Additional features important to the commercial BAU are increasing overall electricity intensities and decreasing natural gas intensities. In the industrial sector, overall electricity and natural gas intensities decrease. Industrial sub-sector shares change slightly. Modeling electricity generation in the BAU scenario is particularly challenging given the high level of uncertainty that currently characterizes California's power sector. Based on California Energy Commission's most recent Electricity Outlook (CEC, 2002a), the BAU incorporates significant construction of new natural gas plant between 2000 to 2005 and more moderate level of construction between 2006 and 2020. The BAU also incorporates modest construction of new renewable generating capacity.

Table 3.6 Driving Assumptions of the Business-as-Usual Scenario

BUSINESS-AS-USUAL (BAU) ASSUMPTIONS	
RESIDENTIAL	Population and number of households increase. The economy grows steadily and real personal incomes rise. Household use of computers and printers reach levels of TVs and VCRs by 2020. Refrigerator sizes increase. A greater percentage of homes use air conditioning. Natural gas efficiencies improve for space & water heating technologies Homes use less wood for space heating.
TRANSPORTATION	Population increases. Vehicles are driven with the same number of passengers per car. People drive more miles per year . Light duty trucks/SUVs become more popular than cars. Hybrid and electric vehicles penetrate the market to a modest level. Vehicle average fuel economy does not improve (gas/diesel). Air travel per person increases. Energy intensity of air travel decreases. Freight activity per person increases. The composition of freight activity remains the same (% rail, road, water) Freight vehicle fuel economies remain unchanged.
COMMERCIAL	Commercial floorspace increases. The composition of building types remains constant. Saturations of end uses remain constant. Electricity intensities increase overall. Natural gas intensities decrease overall.
INDUSTRIAL	Industrial value of shipments increases. Industrial sub-sector shares of total industrial value of shipments change slightly. Electricity and natural gas intensities decrease overall.
ELECTRICITY GENERATION	Significant numbers of new natural gas power plants are constructed: 2000-2005. Moderate construction natural gas plants: 2005-2020. Modest construction of renewable plants: 2000-2020. Minimum import level set to current level of coal generation imports.

The detailed results and assumptions of each demand sector and electricity generation sector for the BAU and alternative scenarios are presented later in this section. The general assumptions are presented here to serve as a road map before beginning more detailed discussion.

3.5 Overview of Alternative Scenarios

The BAU scenario serves two particularly important functions in the context of developing and interpreting the alternative scenarios. First, the BAU provides a reference scenario based around "official" expectations about the future. Using the BAU as a point of comparison for the alternative scenarios situates the scenario results within the context of state-level forecasts. The use of a common framework makes it possible to actively open up discussion around both forecasts and alternative scenarios. Secondly, the BAU serves as a set of reference parameters within the scenario modeling framework. When alternative scenario assumptions are not provided, the BAU provides the default assumptions for the alternative scenarios. A summary of the assumptions underlying the alternative scenarios is presented in the table below.

Table 3.7 Important Elements of the Alternative Scenario Modeling Assumptions

ALTERNATIVE SCENARIO ASSUMPTIONS			
	SPLIT PUBLIC	GOLDEN STATE	PATRIOTIC ENERGY
RESIDENTIAL	Activity level of 50% of public by 2020 - Solar water heaters - Use of clothes lines - Energy efficient lighting - Residential solar systems	Activity of 30% of public by 2020 - Solar water heaters - Use of Clothes lines - Energy Efficient lighting - Residential solar systems	Same activity level as Split Public, however motivated by patriotic interest in U.S. international fuel dependence
TRANSPORTATION	Penetration of existing alternative transportation technologies: - 50% hybrid & electric vehicles by 2020	Penetration of existing alternative transportation technologies - 30% hybrid & electric vehicles by 2020 Hydrogen transportation remains undeveloped	2000-2010: Significant penetration of hybrid and electric vehicles 2010-2020: Penetration of direct-Hydrogen fuel cell vehicles to 75% by 2020 - Increased fuel economy for freight trucks
COMMERCIAL	Municipal solar and wind activities offset commercial and residential electricity demand	Municipal solar and wind activities offset commercial and residential electricity demand; Less aggressive than Split Public	- Same level of activity as Split Public
INDUSTRIAL	- Same as BAU	- Same as BAU	- Same as BAU
ELECTRICITY GENERATION	- Same as BAU	- Introduction of 20% renewable energy market share by 2010 (RPS) - No minimum electricity import level; state values self-sufficiency and only imports to meet shortfall - Moderate construction of new natural gas - Endogenous capacity additions of wind and waste-to-energy (WTE) to meet demand	- 20% RPS by 2010 - No Import target - California sets a minimum export level, as the state becomes an exporter of "clean" electricity - Moderate new natural gas - Endogenous capacity additions of wind, solar, and waste-to-energy (WTE)

Note: Waste-to-Energy (WTE) includes electricity generated from biomass, digester gas, landfill gas, and municipal solid waste.

Split Public is characterized by an organized segment of the population initiating clean energy activities on the individual and local levels. Thus, the residential, transportation, and to lesser extent commercial sectors are central to this scenario. The industrial sector and larger scale electricity generation are outside of local control and remain unchanged relative to the BAU scenario. Important features of this scenario include significant adoption of solar water heaters, solar home systems and energy efficient lighting in the residential sector. A segment of the public actively adopts hybrid and electric vehicles. Municipal solar and wind activities by communities with strong public leadership are also important activities in offsetting commercial electricity demand.

Golden State is a scenario of integrated activity on individual, local, and state levels. A cooperative approach means that changes in the residential, transportation, and commercial sectors occur more slowly than in Split Public, however individual and local activities remain important. The interesting feature of Golden State is progressive state energy policy in electricity generation. The state is able to learn from the earlier energy crisis, and comes out of this era empowered and capable of providing a vision and leadership for the 21st century. The state introduces and exceeds a 20% renewable energy electricity market share, or renewable portfolio standard (RPS) by 2010. Renewable energy generation becomes an important part of California's power sector. This is an aggressive scenario in terms of renewable penetration into the electricity sector. Scenarios provide a valuable opportunity to explore a range of options. The expectation of aggressive construction of natural gas power plants in the BAU scenario warrants consideration of alternative scenarios which aggressively pursue renewable energy. Golden State provides this context.

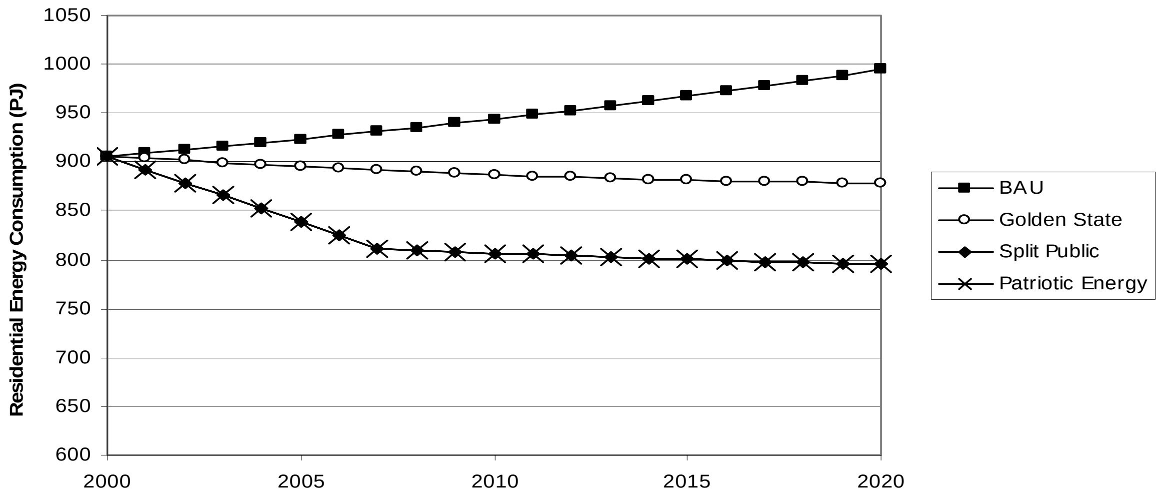
Patriotic Energy is a world of aggressive energy activities and energy policies, particularly in the transportation sector, as the country puts significant effort into reducing oil dependence. Hybrid and electric vehicles become important parts of the near-term response to oil supply insecurity and fragmentation of the international political and economic structures. Immediate increases in fuel economy standards for freight trucks are also important components of this scenario. At the same time, the U.S. aggressively pursues commercialization of direct hydrogen fuel cells. By 2010 the first fuel cell vehicles are available for sale and by 2020, they achieve dominant market share of 75%. The residential and commercial sectors are also active demand sectors. They pursue similar activities as Split Public. However, in this scenario the public is motivated by patriotism and "doing their part" rather than for environmental or local quality of life interests. In Patriotic Energy, the power sector relies more heavily on coal in much of the U.S. in the near term, however, there is aggressive parallel activity to develop renewable energy in a serious way – both for electricity generation and for Hydrogen gas production. The nation adopts a 20% RPS by 2010. In order to achieve this market share, electricity export from states with more developed renewable generation sectors to more fossil dependent states becomes important. California becomes a net exporter of electricity and national model for diverse power generation.

The scenarios results explore different assumptions about the future. In each scenario, sectors and activities take on different roles and different levels of significance. The remainder of this section takes a closer look at how different assumptions about the future affect the way that energy and fuels may be produced and used in California over the next twenty years. In doing so, the scenarios illuminate opportunities and sensitivities of clean energy activities overall and within individual sectors.

3.6 The Residential Sector

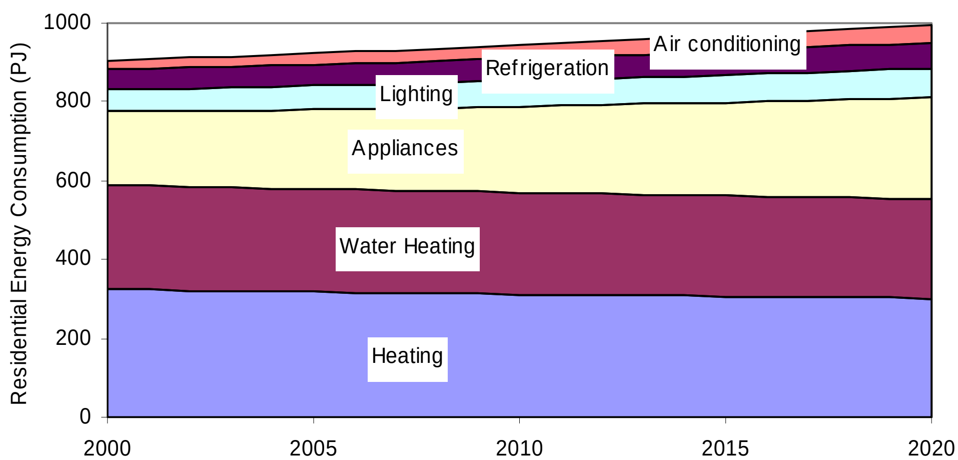
Residential energy consumption demonstrates markedly different trends under each scenario. Business-as-usual leads to 0.5% growth over the next twenty years. Split Public and Patriotic Energy show net decreases in residential energy consumption. Golden State shows effectively flat residential energy consumption over the next twenty years.

Figure 3.5 Residential Energy Consumption (PJ)



In the BAU scenario, increasing population and increasing real personal incomes are expected to lead to more energy consuming households and increasing levels of energy consumption per household. Residential consumption is dominated by space heating, water heating, and appliance end-uses. Lighting, refrigeration, and air-conditioning make up smaller shares. Over the next twenty years, both appliance and air conditioning end-use shares are expected to increase overall. Additional home computers and other electricity using appliances and increasing use of air conditioning underpin growth in energy consumption per household. Efficiency improvements in natural gas heating technologies outpace growth in population and lead to slight decreases in natural gas consumption overall and effectively flat energy consumption patterns over the next twenty years.

Figure 3.6 Residential Energy Consumption: Business-as-Usual (PJ)



The alternative scenarios incorporate the assumptions of the BAU, however each alternative scenario also includes household level energy efficiency and renewable energy activities which generate energy savings relative to the BAU. In the case of Golden State, 30% adoption of solar water heaters, efficient lighting, solar home generation systems, and clothes lines (15%) by the year 2020, offset increases in population and increases in penetrations of air conditioning, computers, and other appliances. More aggressive levels of activity that achieve 50% by 2020 in Split Public and Patriotic Energy scenarios lead to significant energy savings and reductions in consumption relative to current levels, even under conditions of increasing population and personal incomes. An overview of the scenario residential assumptions is detailed in the following table.

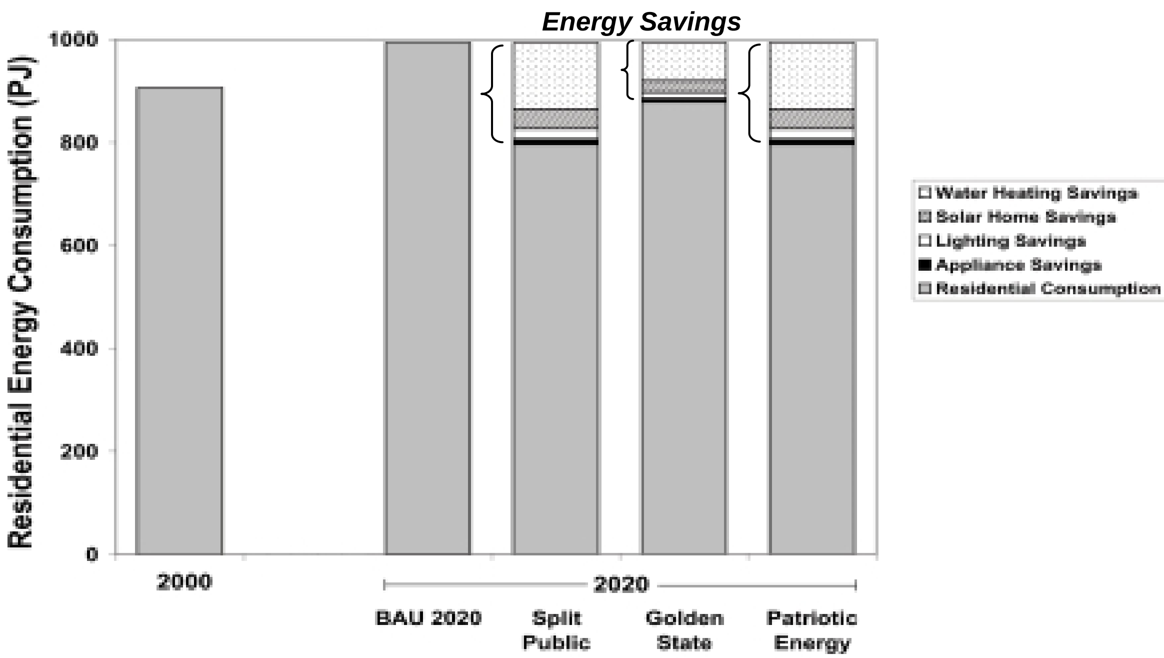
Table 3.8 Residential Sector Scenario Assumptions

Residential Assumptions	
Business-as-Usual	
Activity Driver:	Households grow (1.3%)
Fuels:	Electricity consumption increases (1.7%/yr) Natural gas consumption decreases (-0.1%/yr)
Appliances:	Home computer penetrations to current level of TVs by 2020 (98%) 2nd computer penetrations to current level of 2nd TV's by 2020 (63%) 2nd computers run 25% less than primary computers Printers reach level of current penetration of VCRs by 2020 (89%)
Air Conditioning:	Air-conditioners achieve 70% saturation of households by 2020
Refrigeration:	Larger size refrigerators increase energy intensity of primary refrigerators (+0.2%/yr)
Space & Water Heating:	Natural gas intensities decrease (-1.7%/yr) Woodstove & fireplace primary heating penetrations decrease to 2% by 2020 Woodstove & fireplace auxiliary heating penetrations decrease to 25% by 2021 Woodstove & fireplace primary & auxiliary heating energy intensities decrease (-2%/yr)
References:	(CEC, 2000a), (CEC, 2001a)
Alternative Scenarios	
SPLIT PUBLIC	Increasing use of solar water heaters: 30% by 2007, 50% by 2020 Clothes lines use 1/2 the time by 2020: 15% by 2007, 25% by 2020 Increasing use of CFLs : 30% by 2007, 50% of lighting by 2020 Solar home generation: 50% of households by 2020 (960 W/household)
GOLDEN STATE	Increasing use of solar water heaters: 30% of water heating by 2020 Clothes lines use 1/2 the time by 2020: 15% of clothes drying by 2020 Increasing use of CFLs : 30% of lighting by 2020 Solar home generation: 30% penetration of households by 2020 (960 W)
PATRIOTIC ENERGY	Same as Split Public

Each of the alterative scenarios leads to significant energy savings relative to the BAU scenario. The bar chart shows the change in residential energy consumption between 2000 and 2020 for the BAU and alternative scenarios. Total residential energy consumption increases by about 10% in the BAU scenario between 2000 and 2020. In the same period, residential energy consumption decreases in each of the alternative scenarios. Split Public and Patriotic Energy demonstrate the greatest energy savings – achieving approximately 20% savings relative to the BAU. Golden State achieves approximately 12% savings.

Of the alternative scenario residential activities, the adoption of solar water heaters has the greatest impact, representing more than 65% of total energy savings in 2020. Solar home systems comprise 19% of savings, followed by efficient lighting 11% and Appliances (clothes line use) 5%. The alternative scenarios demonstrate that all of these activities represent viable opportunities for residential energy savings. Solar water heaters present the greatest opportunity for overall savings. Significantly, individual household activities in aggregate generate significant overall energy savings. Even activities as mundane as using clothes lines for 25% of clothes drying have a measurable effect on residential energy consumption.

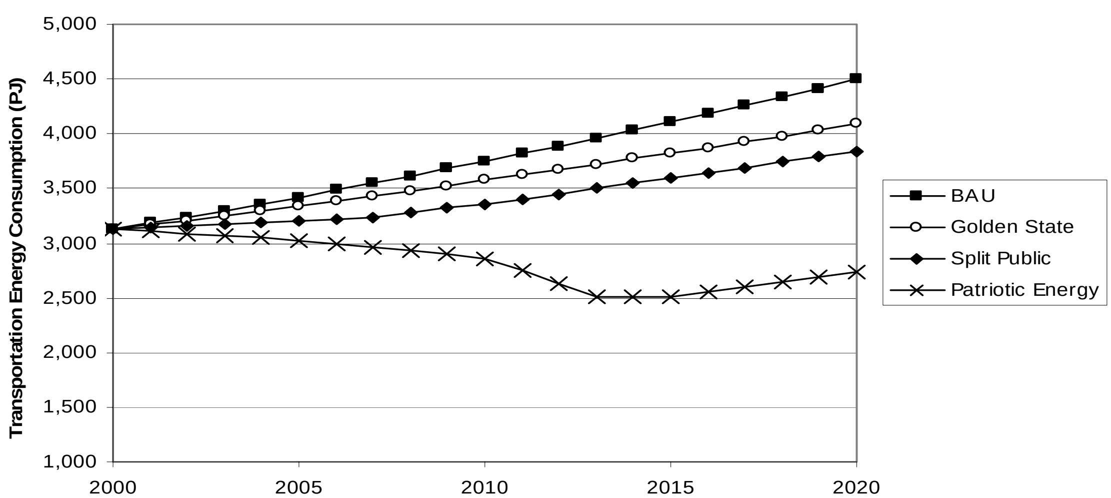
Figure 3.7 Residential Energy Consumption & Savings (PJ)



3.7 The Transportation Sector

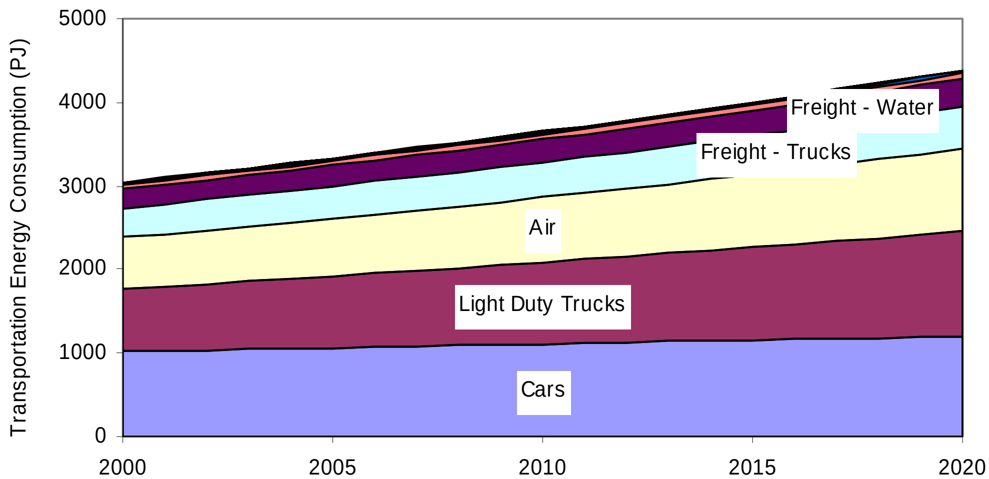
Transportation energy consumption under BAU conditions has the most rapid rate of growth of any of the demand sectors. Growing at an average of 1.8% per year, transportation energy consumption reaches more than 4,500 PJ in 2020 in the BAU scenario. All of the alternative scenarios result in energy savings relative to BAU. These savings are led by Patriotic Energy which shows a net decrease in energy consumption relative to current levels. In Golden State and Split Public, alternative transportation activities decrease the rate of increase in transportation energy consumption from 1.8% per year to 1.0% and 1.4% per year, respectively.

Figure 3.8 Transportation Energy Consumption (PJ)



Cars and light-duty trucks make up the largest fractions of transportation energy consumption. In the BAU scenario, light-duty trucks, particularly SUVs, become more popular, surpassing cars in their fraction of total vehicles stocks. As a result, light duty trucks become responsible for an ever increasing share of transportation energy consumption. Driving, freight, and air travel all increase on an absolute and per capita basis. Alternative fuel vehicles achieve very modest penetrations into car, light-truck, and bus vehicle stocks. Car, light duty truck, and freight truck fuel economies stay constant, however increasing use of light duty trucks results in an overall decrease in the average vehicle fleet fuel economy.

Figure 3.9 Transportation Energy Consumption: Business-as-Usual (PJ)



The alternative scenarios each adopt either fuel efficiency and/or alternative fuel transportation technologies. The alternative scenarios generate energy savings relative to BAU conditions where alternative transportation technologies do not achieve noticeable market penetrations and the average fleet fuel efficiency decreases due to increasing popularity of light trucks. Split Public and Golden State focus on existing transportation technologies. Patriotic Energy is the more aggressive scenario, and provides a context where fuel cells are rapidly developed and commercialized. The assumptions guiding the BAU and alternative scenarios are presented in the table below.

Table 3.9 Transportation Sector Scenario Assumptions

Transportation Assumptions	
Business-as-Usual	
Activity Driver:	Passenger miles traveled per person increases (0.4%/yr) Freight ton miles traveled per person increases (0.4%/yr) Vehicle miles traveled per person of air travel increases (+1.7%/yr)
Fuels:	Gasoline consumption increases for road travel (1.6%/yr) Diesel consumption increases for road travel (2.4%/yr) Jet fuel consumption increases (3.4%/yr) Electricity consumption increases (9%/yr) Natural gas consumption increases (6.1%/yr)
Passenger:	Light duty trucks reach 44% of personal road vehicles by 2020 Hybrid-gas cars reach 6% share of cars Electric cars reach 4% share of cars Hybrid-gas light duty trucks/SUVs reach 4% share of light trucks Electric light duty trucks/SUVs reach 1% share of light trucks Hybrid buses reach 6% of buses CNG buses reach 5% of buses Electric buses reach 2% of buses
Air:	Energy intensity of air travel decreases (-0.7%/yr)
Freight:	Technologies stay the same

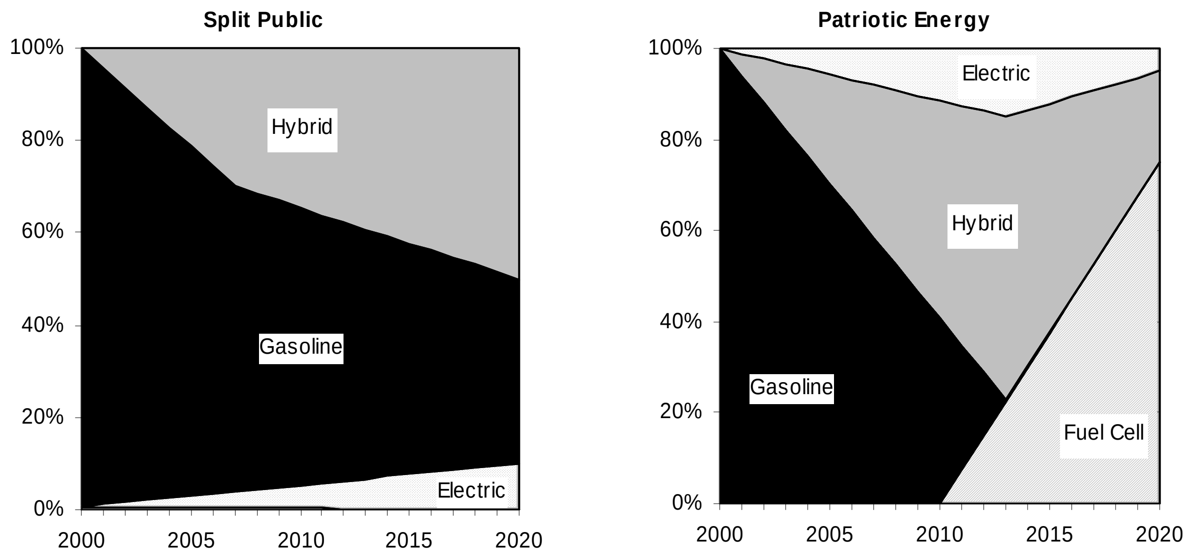
References:	(CEC, 2001c)
Alternative Scenarios	
SPLIT PUBLIC	Trucks percentage increases to 40% (vs. BAU 44%) Hybrid and electric vehicles to 60% cars, 40% trucks, 50% buses Hybrid cars to 30% by 2007, 50% by 2020 Electric cars: to 10% by 2020 Hybrid trucks to 25% by 2007, 35% by 2020 Electric trucks: to 5% by 2020 Hybrid bus to 35% by 2020 CNG bus to 10% 2020 Electric bus to 5% by 2020
GOLDEN STATE	Trucks percentage to 42% (vs. BAU 44%) Hybrid and electric vehicles to 40% cars, 30% trucks, 30% buses Hybrid cars to 30% by 2020 Electric cars: to 10% by 2020 Hybrid trucks to 25% 2020 Electric trucks: to 5% by 2020 Hybrid bus to 20% by 2020 CNG bus to 7% 2020 Electric bus to 3% by 2020
PATRIOTIC ENERGY	Light duty trucks fraction decreases to 20% in 2020 Short-term adoption of hybrid & electric vehicles Medium-term fuel cell car, truck, and bus adoption 0 to 75% by 2020 Standard car, truck, and buses phased out entirely: 2013 for cars, 2010 for buses, and 2015 for trucks Increases in freight truck fuel economy 2x by 2010, 3x by 2020

The central feature of the alternative scenarios is adoption of alternative fuel vehicles. Each of the scenarios does so in different ways. Split Public and Golden State focus on local and state arenas of activity. In terms of transportation, this means that these scenarios focus on adoption of alternative fuel personal and city vehicles – namely hybrid, electric, and CNG vehicles. In Split Public, they achieve 50% penetration overall of cars, light duty trucks, and buses by 2020. In Golden State, the integrated planning approach moves more slowly, achieving 30% penetration by 2020. Without activity on the national level, fuel economy of gasoline and diesel road vehicles (personal and freight) remain the same. Also, Hydrogen transportation technologies remain undeveloped - an "interesting idea" for the far off future.

Patriotic Energy provides a scenario context for national transportation leadership. Concerns about security provide the impetus for rapid changes in the transportation industry, consumer preferences, and policy context. Between 2000 and 2010, the composition of vehicles shifts dramatically toward hybrid and electric vehicles. Aggressive freight truck fuel economy standards are implemented. Another significant change is a decreasing, rather than increasing, proportion of passenger vehicles that are light duty trucks. In the Patriotic Energy future, there is a preference for efficient vehicles a preference away from many vehicles characterized as light duty trucks. In this scenario, commercialization of fuel cells becomes a national security priority – with extensive research and commercialization support to industry being fueled by national technology transfer programs and significant infusion of investment from national government. By 2010, fuel cells are introduced on the retail market, and by 2020 they achieve 75% market share.

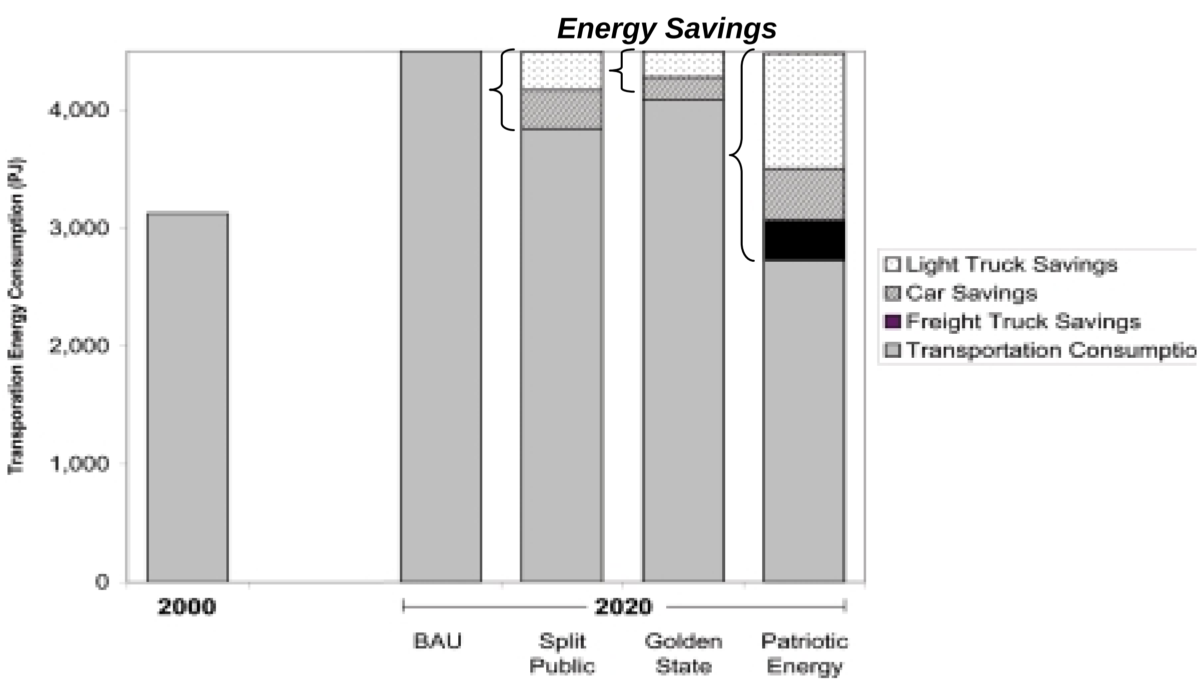
The figures below show the changing composition of car technologies in Split Public and Patriotic Energy. Split Public is characterized by penetrations of hybrid and electric vehicles. Patriotic Energy sees rapid penetrations of fuel cell vehicles after 2010.

Figure 3.10 Composition of Car Technologies in Alternative Scenarios



Increasing the composition of alternative fuel vehicles – cars, light duty trucks, and buses - results in significant fuel savings relative to the BAU. The figure below shows the total transportation consumption and the composition of energy savings for the base year and each scenario in 2020. Each of the alternative scenarios achieves significant energy savings relative to the BAU scenario in 2020.

Figure 3.11 Transportation Energy Consumption & Savings (PJ)



the transportation sector. By 2020, gasoline and diesel cars and light duty trucks have been completely phased out and replaced by fuel cell, hybrid, and electric vehicles. As well, the fraction of light duty trucks decreases from almost 40% in 2000 to 20% by 2020, as efficient vehicles become more popular, and consumer preferences shift toward cars and away from heavier vehicles. Increasing the fuel economy of freight trucks, to twice current values by 2010 and three times current values by 2020, also generates significant energy savings. Overall, light duty trucks demonstrate the greatest energy savings potential.

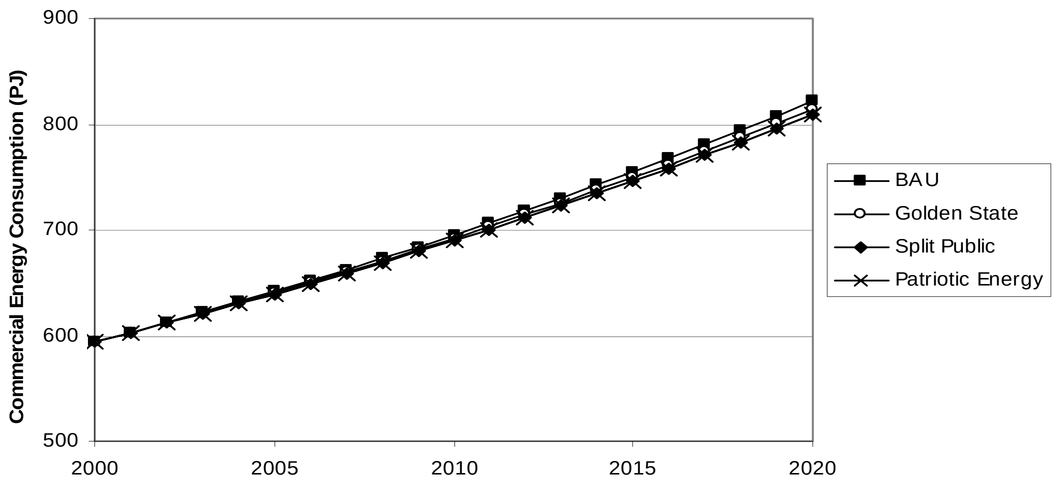
All of the alternative scenarios represent aggressive transportation pathways relative to current trends and use patterns. The scenario analysis is significant in demonstrating, first, that significant opportunities do exist in this sector. However, realizing these savings will require a combined effort by consumers, automakers, and government. At the same time, these results show how even scenarios with significant penetrations of alternative vehicles, like Split Public and Golden State, only serve to decrease the rate of increase of growth of transportation energy consumption. Patriotic Energy is inarguably a very aggressive scenario relative to current trends. It represents a full phase out of gasoline and diesel cars and light duty trucks over the next twenty years with a technology not yet commercialized and a fuel whose infrastructure is not yet developed. This scenario also depends on rapid development of renewable energy based production of hydrogen. All of these assumptions are quite dramatic for the next twenty years. Even so, this scenario leads to only a 9% reduction relative to current transportation consumption.

These results show that to reduce future transportation energy consumption – and all of the air quality, pollution, and fuel dependence issues that accompany it - will require significant and dramatic changes to the transportation sector. In this context, alternative transportation pathways that are currently considered “aggressive” will not likely be considered aggressive in the future. Rather, alternative transportation activities will represent necessary and valuable changes to address the energy consumption, fuel dependence, and air quality concerns of the future. All of these results indicate the enormous challenge that transportation presents to energy security, quality of life, and the environment in California and the U.S.

3.8 The Commercial Sector –

In the BAU scenario, commercial energy consumption increases at a rate of 1.6% per year, driven largely by increases in commercial floorspace and increasing energy intensities of electricity and natural gas per square foot. The alternative scenarios result is small, yet visible, decreases in commercial energy consumption over the next 20 years. The energy savings of the alternative scenarios result from municipal renewable energy activities which offset commercial electricity consumption.

Figure 3.12 Commercial Energy Consumption (PJ)



In the alternative scenarios, municipal renewable energy activities within numerous communities across the state follow the lead of San Francisco whose passage of renewable energy propositions in 2001[10] are expected to generate significant new municipal solar and wind activities. A large number of cities begin developing solar and wind technologies to offset electricity demand of city buildings. They also become "wheelers" of electricity and renewable energy products for residents and commercial businesses. In the alternative scenarios, numerous city programs are developed to facilitate purchase, implementation, and management of solar power generation technologies for businesses and residences. The commercial scenario assumptions are presented in the table below.

Table 3.10 Commercial Sector Scenario Assumptions

Commercial Assumptions	
Business-as-Usual	
Activity Driver:	Commercial floor space increases (1.5%/yr)
Fuels:	Electricity consumption increases (2.0%/yr) Natural gas consumption increases (1.1%/yr)
Energy Intensities:	Variable electricity & natural gas intensities
References:	(CEC, 2001d)
Alternative Scenarios	
SPLIT PUBLIC	Municipal solar activities (bond measures, etc) – leads to 600 MW wind by 2020, 1240 MW solar by 2020; 20x level expected from San Francisco Prop B & H
GOLDEN STATE	Municipal solar activities (bond measures, etc) – leads to 360 MW wind by 2020, 744 MW solar by 2020

[10] Residents of San Francisco in November, 2001 voted to approve two bond measures via Propositions B and H which are expected to provide financing for about 60 MW of solar power, 30 MW of wind generation.

	12x level expected from San Francisco Prop B & H
PATRIOTIC ENERGY	Same as Split Public

3.9 The Industrial Sector

Industrial consumption is expected to grow by 1.1% over the next twenty years, as the industrial value of shipments increases and electricity and natural gas consumption increase. The alternative scenarios adopt the BAU assumptions. In Split Public, activities are confined to individual and community activities. In Golden State and Patriotic Energy, the industrial sector is not a focus of activities. Detailed consideration of alterative industrial scenarios represents an opportunity for future work. The table below presents the industrial scenario assumptions.

Figure 3.13 Industrial Energy Consumption (PJ)

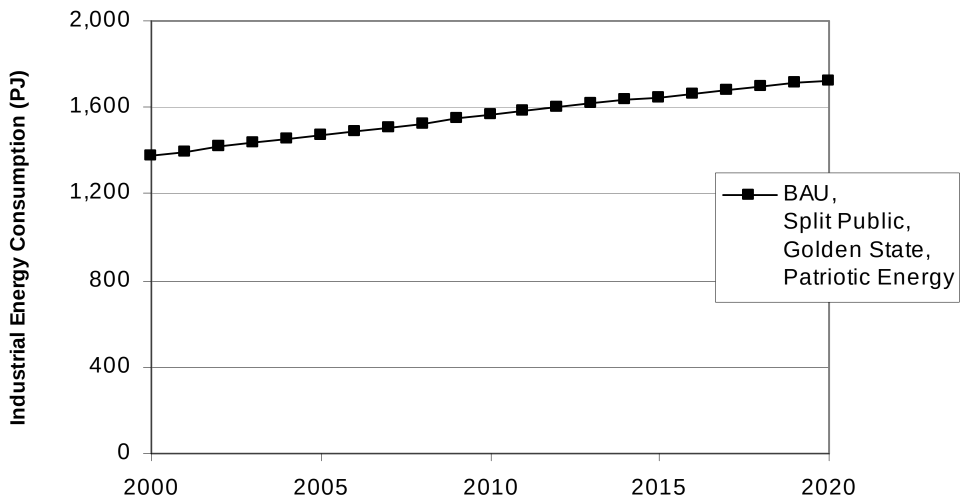


Table 3.11 Industrial Sector Scenario Assumptions

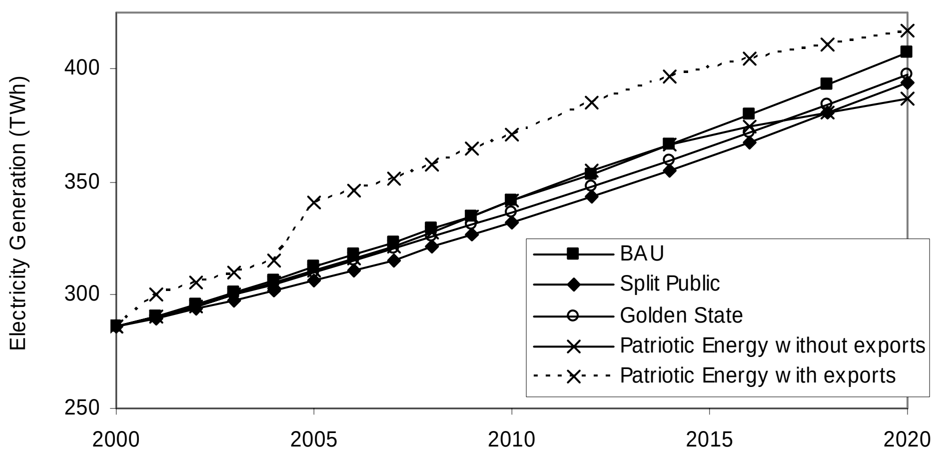
Industrial Assumptions	
Business-as-Usual	
Activity Driver:	Value of shipments increases (4.0%/yr)
Fuels:	Electricity consumption increases (1.7%/yr) Natural gas consumption increases (1.1%/yr)
Energy Intensities:	Variable sub-sector shares of industrial value of shipments, see table for details Variable electricity & natural gas intensities, see table for details
References:	(CEC, 2001e)
Alternative Scenarios	
SPLIT PUBLIC	Same as BAU
GOLDEN STATE	Same as BAU
PATRIOTIC ENERGY	Same as BAU

3.10 Electricity Generation

3.10.1 Overview

All of the energy scenarios show steady increases in electricity generation over the next twenty years, growing on average rates of 1.5% to 1.8% per year. Less electricity generation is required to serve state demand in Split Public, Golden State, and Patriotic Energy relative to the BAU scenario. Split Public, Golden State, and Patriotic Energy achieve electricity demand reductions through energy efficiency and distributed renewable energy generation activities which offset electricity demand at the point of use. In Split Public, activities are confined to individual and local arenas, so the composition of state power sector remains the same as BAU. In contrast, Golden State and Patriotic Energy take on significant clean energy activities in the power sector. In Patriotic Energy, the state also begins exporting renewable-based electricity to other states. California is able to benefit from a diverse generation portfolio and supply renewable energy based generation and credits to other states. Export of electricity in Patriotic Energy leads to a higher overall level of electricity generation depicted in the figure below.

Figure 3.14 Electricity Generation (TWh)



In the California scenarios model, electricity is generated to meet electricity demand requirements of the individual demand sectors. The electricity generation module uses explicitly specified technology categories and attributes as well as a specified merit order, annual system load curve[11], and import and export requirements to meet the total annual electricity demand resulting from each set of scenario assumptions. In the California Scenarios model, the base year composition of generation technologies and generation output of California's power sector is built from existing state-level power plant data from the California Energy Commission, U.S. Environmental Protection Agency, and U.S. Department of Energy - see (CEC, 2001g), (EPA, 2001), and (DOE 2001c/d). Future capacity additions under each scenario are explained in detail in the next sections.

3.10.2 BAU Capacity Additions

Looking to the future composition of California's power sector, current expectations suggest significant construction of new natural gas power plants. (CEC, 2002a) This is in large part a direct response to the

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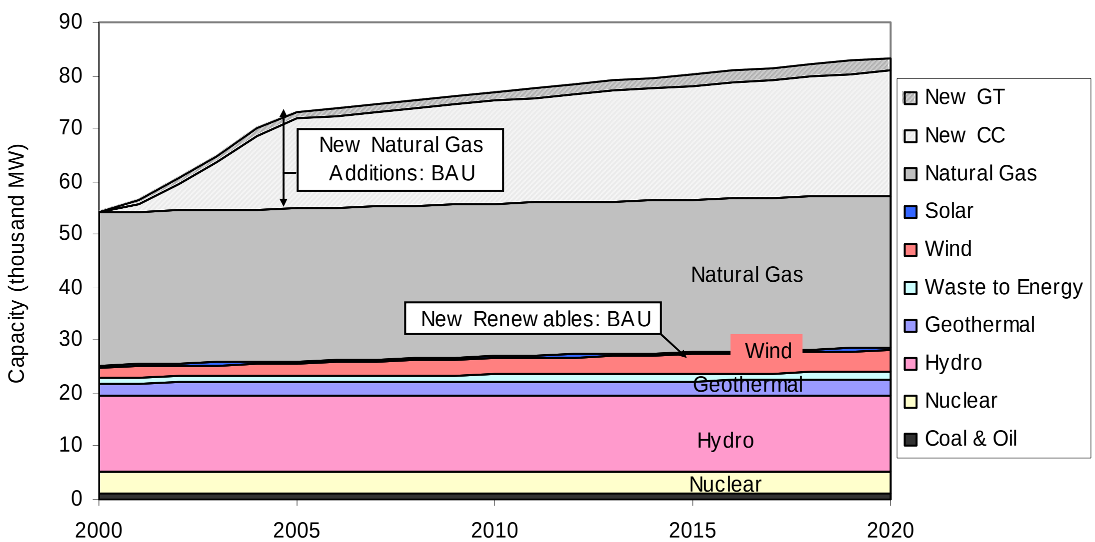
[11] Specified parameters include: technology category, capacity, efficiency, base year generation, maximum capacity factor, capacity value, and merit order.

"Energy Crisis" of 2000 and 2001 which led to increased incentives and fast-track approval of new construction. A significant component of this new construction is also a result of the long-term electricity contracts negotiated with the Department of Water Resources, an estimate of 60% is for power plants which have not yet been built. (Bachrach, 2002) It is unclear exactly how current intentions and expectations will translate in to actual new generation capacity. This is one primary motivation for explore a range of different assumptions in the alternative scenarios.

Future capacity additions in the BAU scenario are based on the most recent California Energy Commission Electricity Outlook Report[12] (2002a) and power plant construction data for 2001 (CEC, 2001). These sources specify additions of more than 18,000 MW of new natural gas generating capacity between 2000 and 2005, almost entirely in the form of new combined-cycle natural gas power plants. In addition, the BAU scenario adds 825 MW of new renewable energy between 2000 and 2005, mainly in the form of wind and waste-to-energy technologies[13]. Looking to the longer-term, the BAU scenario assumes natural gas power plant construction continues at a slower rate between 2006 to 2020, adding an additional 8,000 MW to the state's electricity supply. During the same period, 2,500 MW of new renewable energy capacity is also added. All of these new capacity additions are specified exogenously, thus it is assumed that they will be built independent of demand requirements. The figure below shows how the composition of generation capacity changes over the twenty years of the BAU scenario.

Figure 3.15 Composition of Generation Capacity: Business-as-Usual



The first thing to note in the figure above is large quantity of new natural gas capacity additions over the next five years. In contrast, the new renewable energy additions are barely noticeable relative to the total generation mix. This figure shows clearly that the state expects to become even more reliant on natural gas over the next twenty years. The BAU show that natural gas capacity is expected to almost double by 2020.

Putting these observations into a historical context, the following figure shows the progression of power plant additions in the state since the early 1900's. Historical data are taken from the California Energy

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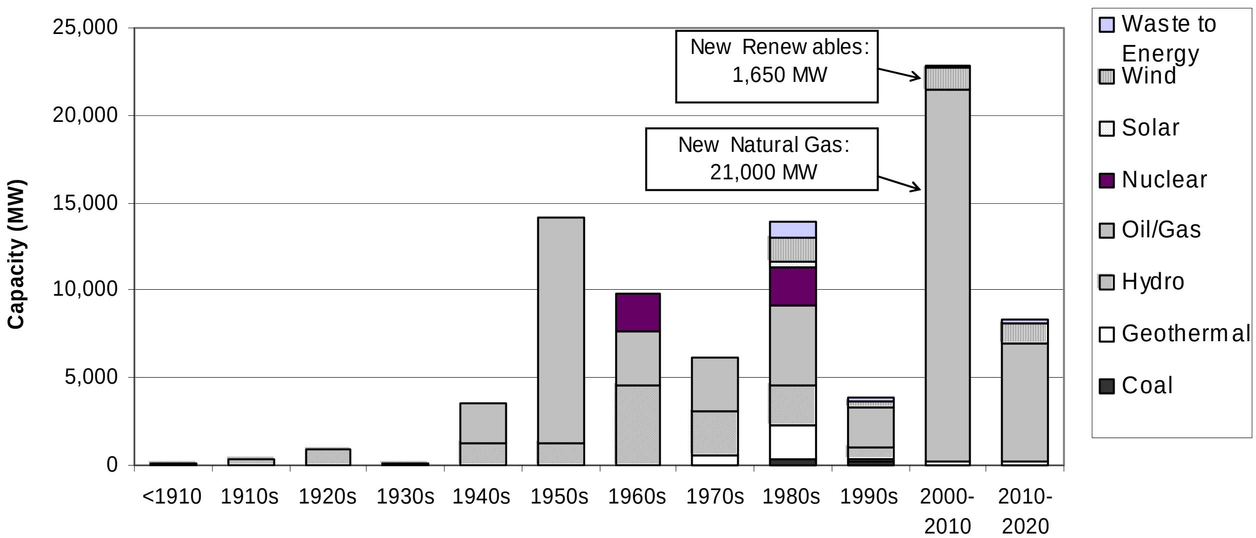
[12] The BAU scenario uses the CEC's "most likely" and "baseline" scenario categories from the to derive capacity additions, see Table I-2 and II-2-1 (CEC, 2002).

[13] Waste-to-Energy is a category used by the California Energy Commission. It includes biomass, digestor-gas, landfill gas, and municipal solid waste technologies.

Commission *Environmental Performance Report of Electricity Generation in California.* (CEC, 2001h) Expected natural gas construction over the next ten years is by far the largest of any other decade in history. The proposed additions are more than double the oil plant construction boom of the 1950's which is looked at as a time of rapid growth in the power sector – it is even considered by many to be a time of over-supply. It is readily apparent from this figure that the proposed natural gas construction is unprecedented. How these expectations actually play out in the future is one of the critical uncertainties to the future development of California's power sector.

Figure 3.16 Power Generation Capacity Additions: Historical and BAU



3.10.3 BAU Import Assumptions

Another critical uncertainty in California's power sector is the role that electricity imports will play in the future. Between 1998 and 2000, California imported between 22% and 30% of its electricity requirements from out of state. (CEC, 2002d) This included varying levels of imports from the Pacific Northwest and Southwest (10-18%) and a more or less constant level of imports from investor-owned out-of-state coal generation plants that supply electricity exclusively to California (10-12%).

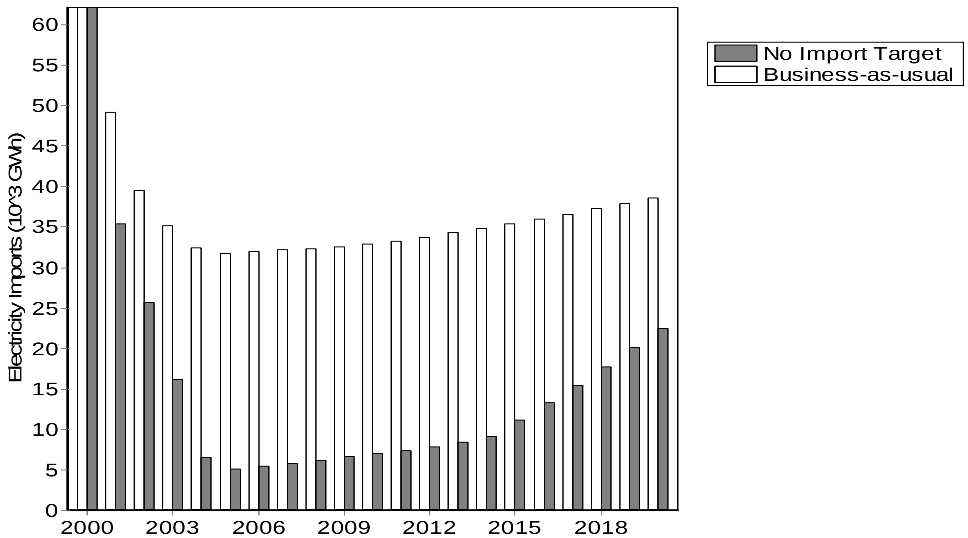
The BAU scenario sets a minimum level of imports at the current level of fixed-coal imports. In the BAU scenario, additional imports occur only when the state cannot meet demand with its in-state generation system. These assumptions do not capture situations when it may be cheaper to flexibly import electricity and leave in-state capacity idle. However, this set of assumptions was chosen for two reasons: 1) it recognizes that some imports are almost guaranteed to occur, and 2) it makes it possible to explore how new capacity additions could potentially offset imports. The following figure shows the resulting electricity imports for each scenario.

It is interesting to note that under BAU conditions, electricity imports drop off rapidly after 2000 to the specified minimum import level of 30,000 GWh,[14] as large amounts of new capacity is added. Removing the minimum import level leads to an even more precipitous drop-off in imports. These results suggest that according to the model assumptions, new capacity additions have the potential to off-set imports. The alternative interpretation may suggest that if imports continue at current levels, with current

[14] The minimum import level for the BAU is equal to the average level of imports from utility-owned, out-of-state coal generation with exclusive sales to California between 1998 and 2000 (CEC, 2002d)

expectations of new construction the state could be entering a time of over-construction and inefficient levels of capacity[15]. All of the remaining results in this paper incorporate the assumption of a minimum import level into the BAU scenario.

Figure 3.17 BAU Electricity Imports: With and Without a Minimum Import Level



3.10.4 Alternative Scenario Assumptions

Split Public is a world with the same power sector as the BAU scenario. In Split Public, activities occur at the individual and local level. Without state and private-sector involvement, changes to the states power sector are not realized. Significant numbers of solar home systems and community based solar and wind generation occurs in Split Public. These activities result in demand offsets at the residential or commercial level. As would likely be the case in practice, the residential and commercial renewable energy activities are evaluated within the demand sector results rather than within the power sector electricity generation results.

Golden State leads to a future where the state is able to coordinate between policy and planning goals, constructing a long-term vision towards increased energy diversity in the power sector. California adopts a mandatory requirement that 20% of power generation, both in-state and imports be derived from renewable energy sources through the passage of a state-level Renewable Portfolio Standard (RPS) legislation. Using life-cycle analysis of the costs and benefits of new construction, the state is able to provide the appropriate signals and incentives to reduce the level of new natural gas construction to about half of the BAU scenario. Based on more integrated accounting and planning, the state eliminates its minimum import level, as the low cost of imports (especially coal) is weighed against other criteria in decision-making. Integrated planning occurs on the state rather than regional level, therefore the state puts an added value on in-state generation as it increases its ability to manage its resources. In addition to natural gas, most of the new capacity added is wind and waste-to-energy.

[15] It is important to state that this model is only a power sector model and therefore cannot capture all of the complexities and real-time trade-offs between economic, fuel, demand requirements that would be required to carefully substantiate this claim. It is suggested here as an important consideration in evaluating the potential implications of California's expected commitments to significant new construction over the next decades.

In Patriotic Energy, states look to California as an example in reducing oil and gas dependence of their power sectors. With energy security and decreasing oil dependence as the primary driving forces, electricity generation becomes an arena of new renewable energy activity. Developing renewables becomes a national priority for two reasons: 1) as a means of conserving natural gas for high value applications like heating, peak load demand, Hydrogen production, and 2) as an increasingly important source of Hydrogen fuels. California, Texas, and the Mid-West become centers of renewable energy power and hydrogen production. These states become net electricity exporters. New renewable energy capacity is primarily wind, solar, and waste-to-energy. The following table summarizes the electricity generation scenario assumptions.

Table 3.12 Electricity Generation Scenario Assumptions

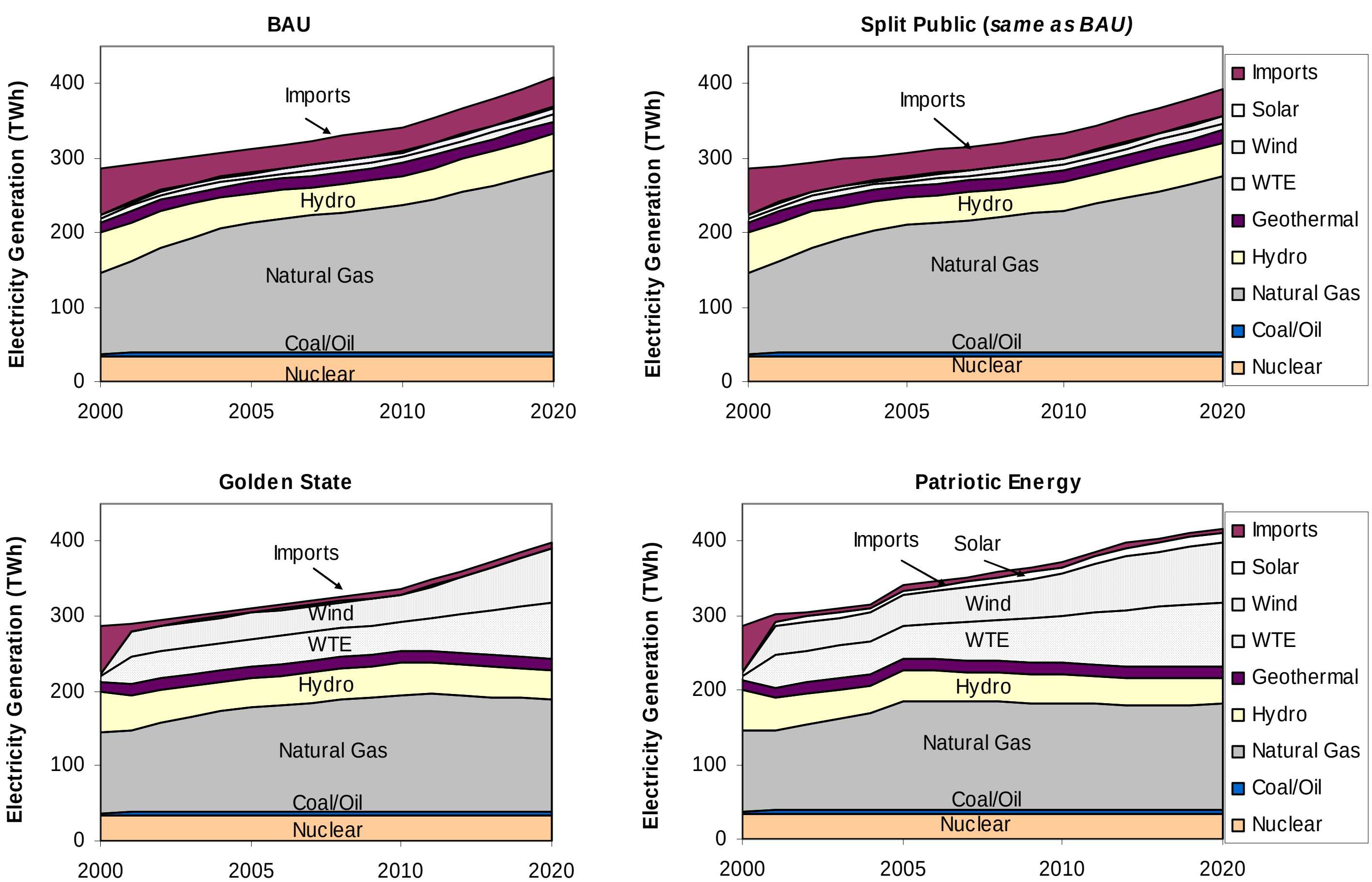
Electricity Generation	
Business-as-Usual	
2000-2005:	New natural gas (primarily combined cycle): 18,000 MW New renewable energy: 825 MW
2005-2020:	New natural gas construction at slower rate: 8,000 MW New renewable energy at same rate: 2,500 MW
Imports:	Set minimum import level at 30 TWh (out-of-state, investor-owned generation) Additional imports to make up an unmet electricity demand
Reserve Margin:	Set Planning reserve margin to 15%, actual reserve margins vary from 10-40%,
References:	(CEC 2001h/f), (CEC, 2002a), (DOE, 2001f)
Alternative Scenarios	
SPLIT PUBLIC	Same as BAU
GOLDEN STATE	Moderate construction of new natural gas (50% of BAU levels) 20% RPS by 2010, endogenous capacity additions of wind and waste-to-energy No minimum import level
PATRIOTIC ENERGY	Moderate construction of new natural gas (50% of BAU levels) 20% RPS by 2010, endogenous additions of wind, solar and waste-to-energy Minimum export level of 30 TWh; CA as "cleaner" than neighboring states

3.10.5 Electricity Generation

The following figure presents the composition of electricity generation for each scenario over the next twenty years. The BAU and Split Public scenarios both show significant increases in natural gas based electricity generation. This new generation reduces imports to their minimum import levels. Slight increases in renewable-based generation occur, though it is difficult to notice these small changes relative to the other elements. Natural gas dominates electricity generation. Nuclear, hydro, and imports make up the majority of the remaining generation.

Golden State and Patriotic Energy both show significant increases in renewable energy based electricity generation. The majority of these increases are captured by wind and waste-to-energy facilities. In addition, in Patriotic Energy, solar is a noticeable generation fraction for the first time. Without a minimum import level in both of these scenarios, imports rapidly drop off, becoming only a small component of generation. Natural gas continues to be an important component of generation, though it is balanced with other fuels. In these scenarios, renewables make up an equally important fraction. Hydro and nuclear generation remain constant. Imports become marginal components of generation.

Figure 3.18 Electricity Generation: BAU and Alternative Scenarios

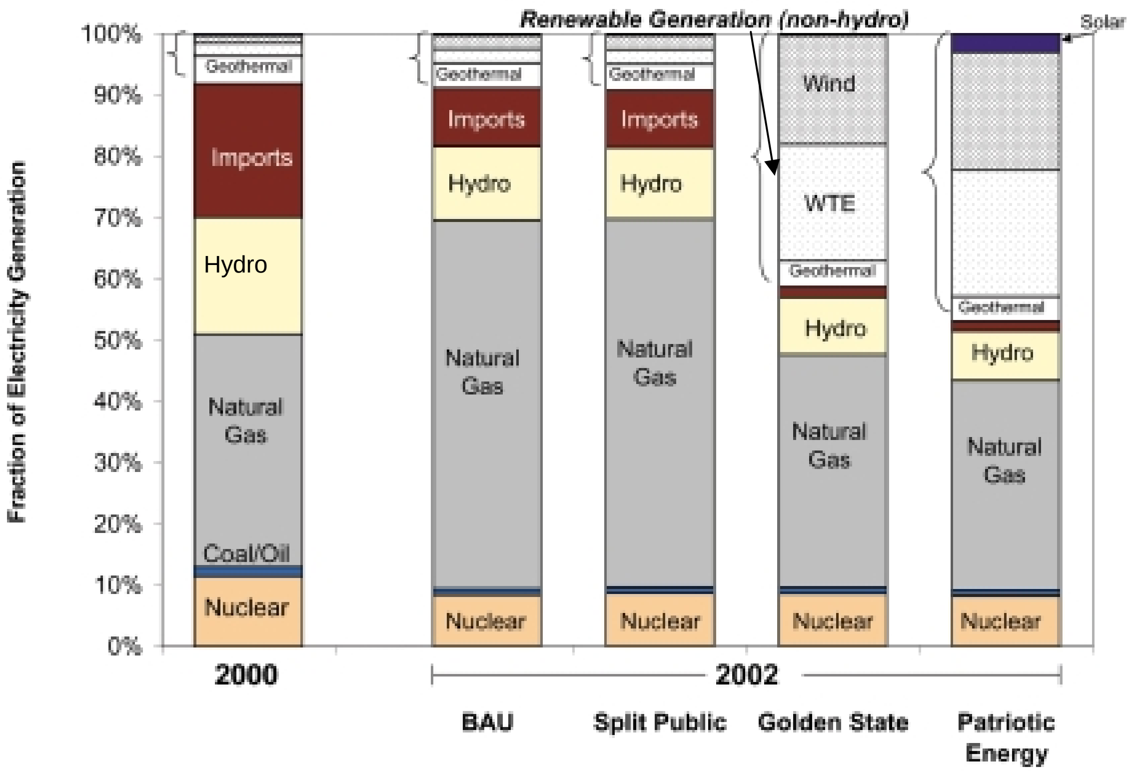


3.10.6 Power Generation Shares

Each scenario leads to a very different composition of future electricity generation. The figure below shows the composition of electricity generation derived from different fuels for the base year and each scenario in 2020. Driven in large part by the introduction of a renewable portfolio standard and a reduction in new natural gas construction, Golden State and Patriotic Energy achieve 41% and 47% generation fractions for renewables by 2020. Both Golden State and Patriotic Energy meet and exceed their renewable portfolio standards of 20% by 2010. These early commitments provide the foundation for cost reductions and technology improvements which encourage the increasing market share by 2020.

One of the most important things to note in the figures below is the significant increase in natural gas dependence of California's power sector in BAU and Split Public scenarios. Its fraction increases from 38% to 60% between 2000 and 2020. Both of these scenarios are futures where the price and availability of natural gas will have an even greater impact on California. Also, according to the scenario and modeling assumptions, new natural gas capacity would more than meet new demand. This creates conditions with the potential for over-capacity and market lock-out for renewable energy sources. This could have destructive implications for the renewables industry in California – both in terms of market share and future cost reductions and technology improvements. Golden State and Patriotic Energy are alternative pathways that lead to constant or decreasing generation fraction of natural gas.

Figure 3.19 Composition of Electricity Generation: Base Year and 2020



The following table outlines the composition of electricity generation for the Business-as-Usual and three alternative scenarios. Most notable is the fraction of natural gas and renewable energy based generation in each scenario. The changing composition of imports and exports is also significant.

Table 3.13 Composition of Electricity Generation: Base Year and 2020

	BAU			
	2000	**2005**	**2010**	**2020**
% Natural Gas	38%	56%	58%	60%
% Renewable *(non-hydro)*	8%	9%	9%	9%
% Hydro	19%	12%	12%	12%
% Nuclear	11%	11%	10%	8%
% Coal/Oil	1%	1%	1%	1%
% Imports	22%	10%	10%	9%
% Exports	0%	0%	0%	0%
Generation (TWh)	286	313	342	408
	Split Public			
	2000	**2005**	**2010**	**2020**
% Natural Gas	38%	56%	58%	60%
% Renewable *(non-hydro)*	8%	9%	10%	9%
% Hydro	19%	12%	12%	12%
% Nuclear	11%	11%	10%	9%
% Coal/Oil	1%	1%	1%	1%
% Imports	22%	10%	10%	9%
% Exports	0%	0%	0%	0%
Generation (TWh)	286	307	332	394
	Golden State			
	2000	**2005**	**2010**	**2020**
% Natural Gas	38%	45%	47%	38%
% Renewable *(non-hydro)*	8%	29%	27%	41%
% Hydro	19%	13%	13%	9%
% Nuclear	11%	11%	10%	9%
% Coal/Oil	1%	1%	1%	1%
% Imports	22%	2%	2%	2%
% Exports	0%	0%	0%	0%
Generation (TWh)	286	310	337	398
	Patriotic Energy			
	2000	**2005**	**2010**	**2020**
% Natural Gas	38%	43%	39%	34%
% Renewable *(non-hydro)*	8%	32%	39%	47%
% Hydro	19%	12%	10%	8%
% Nuclear	11%	10%	9%	8%
% Coal/Oil	1%	1%	1%	1%
% Imports	22%	2%	2%	2%
% Exports	0%	9%	8%	7%
Generation (TWh)	286	341	372	417

The BAU scenario presents a road to the future with increasing natural gas dependence and decreasing energy diversity in California's power sector. Over many years, the state developed one of the most diverse generation portfolios in the state, a key dimension was incorporation of small generators in the 1980s. The BAU scenario shows that this diversity can be quickly reversed and even locked-out of the future. Now is a critical time for exploration of alternatives and careful consideration of the benefits and trade-offs of BAU choices. The alternative scenarios represent a first step at exploring potential alternatives.

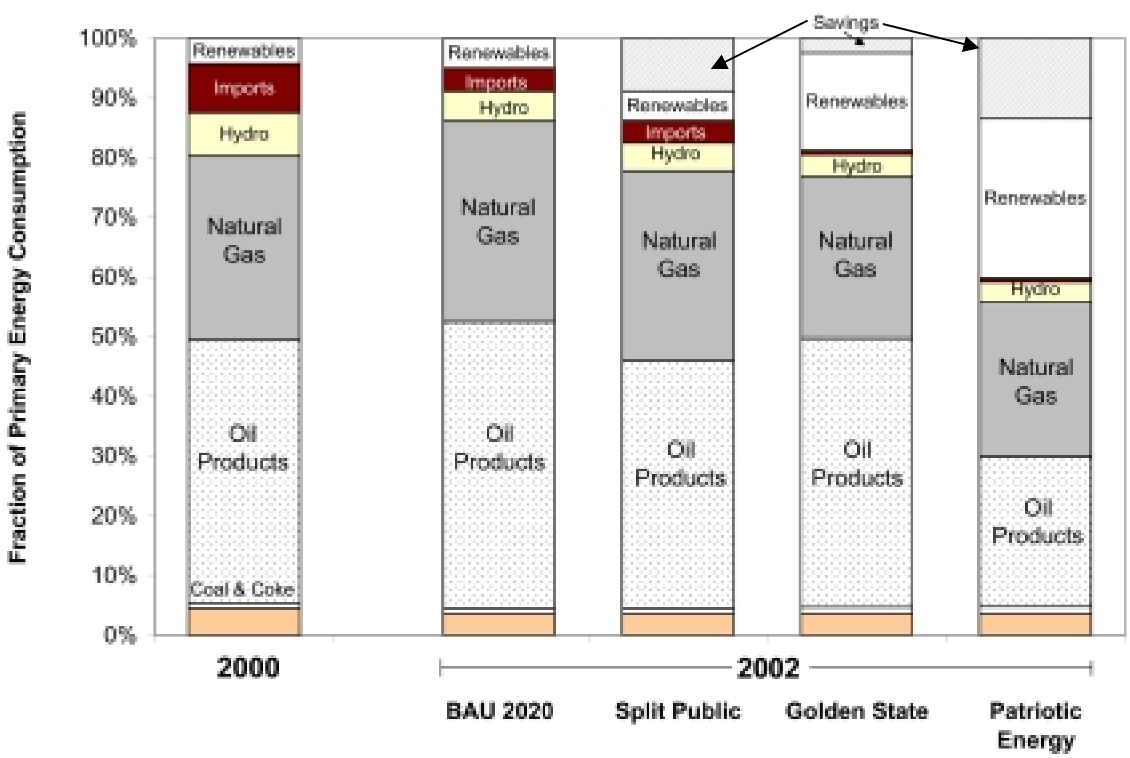
Having considered each of the demand sectors and electricity generation individually, discussion now turns to examine the composition of overall state energy consumption. As the scenarios were originally constructed to explore different ways that energy diversity may become a more important driving force in the future, this section considers the implications of each scenario energy diversity in the state.

3.11 Implications for Energy Diversity

Energy diversity is an important concept for California for a number of reasons. First, energy diversity is an important dimension of supply security. California consumes a large amount of energy, and energy diversity affects what types and how much of each fuel is consumed. Second, the state imports significant quantities of both electricity and primary fuels which have both price and availability risks. Moreover, the state has recently demonstrated that electricity generated within the state can exhibit extensive price and availability risks as well. How well the state is able to use energy diversity to reduce the state's exposure to particular kinds of risk will be an important dimension of the state's future energy pathway.

Also, in the context of California, increasing energy diversity would almost certainly result from decreasing the share of fossil fuel consumption. It is important to note that the concept of energy diversity is not necessarily synonymous with a cleaner energy pathway or a decreased reliance on fossil fuels. Increasing energy diversity only implies a diversification of resources, and diversification can be achieved in many ways. For example, in California increasing coal fuel shares would increase energy diversity, but would certainly not be a cleaner pathway. The implications of energy diversity depend on the context, and can describe many kinds of activities with very different implications. In the context of California, with the state's current level of dependence on oil and natural gas, increasing energy diversity will be at the expense of these two fuels. It is highly unlikely that coal will be a major fuel in California's future. Therefore, in California increasing energy diversity will almost certainly decrease fossil fuel dependence. The figures below show the shares of total primary energy consumption for the base year and each of the scenarios in 2020.

Figure 3.20 Category Shares of Primary Energy Consumption: Base Year and 2020



Thus, in California, increasing energy diversity is directly related to possibilities for non-fossil fuels and alternative technologies - and by association the potential for cleaner energy pathways. For these reasons, this section examines and compares the energy diversity of each of the scenarios. The aim is to consider the extent to which the scenarios present alternatives to business-as-usual futures.

These analyses make two types of efforts to incorporate a more robust assessment of energy diversity in the energy scenarios. First, they include an estimate of primary energy consumption associated with electricity imports. Imports are an important part of California's electricity supply. They can arguably be placed in a separate category for energy diversity, because they have a different risk profile than in-state generation. Due to the significance of electricity imports to California's energy system, it is important that they be represented in an analysis of energy types. Secondly, this analysis makes the effort to expand the focus of diversity and security to consider both supply and demand opportunities. These figures include energy savings as a category share for the alternative scenarios. Just as an increase in the relative share of renewables could displace oil consumption, energy savings through energy efficiency measures or reduced consumption could equally "displace", or rather avoid, the same oil consumption. The most environmentally friendly form of energy is energy saved; and the most secure form of energy supply is energy saved. In the context of discussion of energy diversity, energy savings is an equally important category as fuels.

A quick glance at the relative sizes of each of the category shares in the figure shows that each of the alternative scenarios offer increases in energy diversity relative to the BAU assumption. In Golden State, the change in category shares is slightly more diverse than BAU. In Split Public and Patriotic Energy, the increases in energy diversity are much more visible.

To quantify the extent of energy diversity beyond a simple visual inspection, it is useful to apply a metric to evaluate the energy diversity of each scenario. Neff provides a simple index for assessing diversity based on the classic Herfindhal measure of market concentration (Neff, 1997). A simple index for diversity can be written as:

$$H = 1 / \sum x_i^2$$

Where x_i is the category fraction from source "i". Using this index, the higher the value of H, the greater the energy diversity. The value of H ranges between 1 and the total number of categories. This analysis uses eight categories to characterize primary energy consumption. These categories include: oil products, natural gas, coal/coke, hydropower, nuclear, imports, renewables, and energy savings. With eight categories, the maximum diversity index, or highest value of H would be when all eight categories have equal shares, or $H = 8 = (8*(1/8)^2)^{-1}$ The minimum diversity index corresponds conditions when one category has 100% share, thus $H = 1 = (1^2)^{-1}$. Thus 1 and 8 represent the upper and lower bounds of the possible diversity index values for the scenarios. The following table presents the results of diversity index calculations.

Table 3.14 Primary Energy Consumption and Scenario Diversity Index

	PJ	x_i	x_i^2	Diversity Index		PJ	x_i	x_i^2	Diversity Index
	Year 2000								
Base Year	8,243			3.27					
Imports*	672	0.082	0.0067						
Oil Products	3,634	0.441	0.1946						
Coal & Coke	69	0.008	0.0001						
Natural Gas	2,543	0.309	0.0953						
Hydro	597	0.072	0.0053						
Renewables	355	0.043	0.0019						
Nuclear	368	0.045	0.0020						
Savings	0	0.000	0.0000						
	Year 2020					Year 2020			
BAU	10,722			2.84	**Split Public**	9,772			3.46
Imports*	417	0.039	0.0015		Imports*	396	0.037	0.0014	
Oil Products	5,147	0.480	0.2307		Oil Products	4,454	0.416	0.1728	
Coal & Coke	89	0.008	0.0001		Coal & Coke	89	0.008	0.0001	
Natural Gas	3,610	0.337	0.1135		Natural Gas	3,408	0.318	0.1012	
Hydro	536	0.050	0.0025		Hydro	502	0.047	0.0022	
Renewables	534	0.050	0.0025		Renewables	534	0.050	0.0025	
Nuclear	382	0.036	0.0013		Nuclear	382	0.036	0.0013	
Savings	0	0.000	0.0000		Savings	950	0.089	0.0079	
Golden State	10,458			3.27	**Patriotic Energy**	9,279			4.50
Imports*	72	0.007	0.0000		Imports*	69	0.006	0.0000	
Oil Products	4,823	0.450	0.2026		Oil Products	2,684	0.250	0.0627	
Coal & Coke	120	0.011	0.0001		Coal & Coke	126	0.012	0.0001	
Natural Gas	2,898	0.270	0.0731		Natural Gas	2,778	0.259	0.0672	
Hydro	406	0.038	0.0014		Hydro	369	0.034	0.0012	
Renewables	1,750	0.163	0.0267		Renewables	2,864	0.267	0.0714	
Nuclear	382	0.036	0.0013		Nuclear	382	0.036	0.0013	
Savings	264	0.025	0.0006		Savings	1,443	0.135	0.0181	

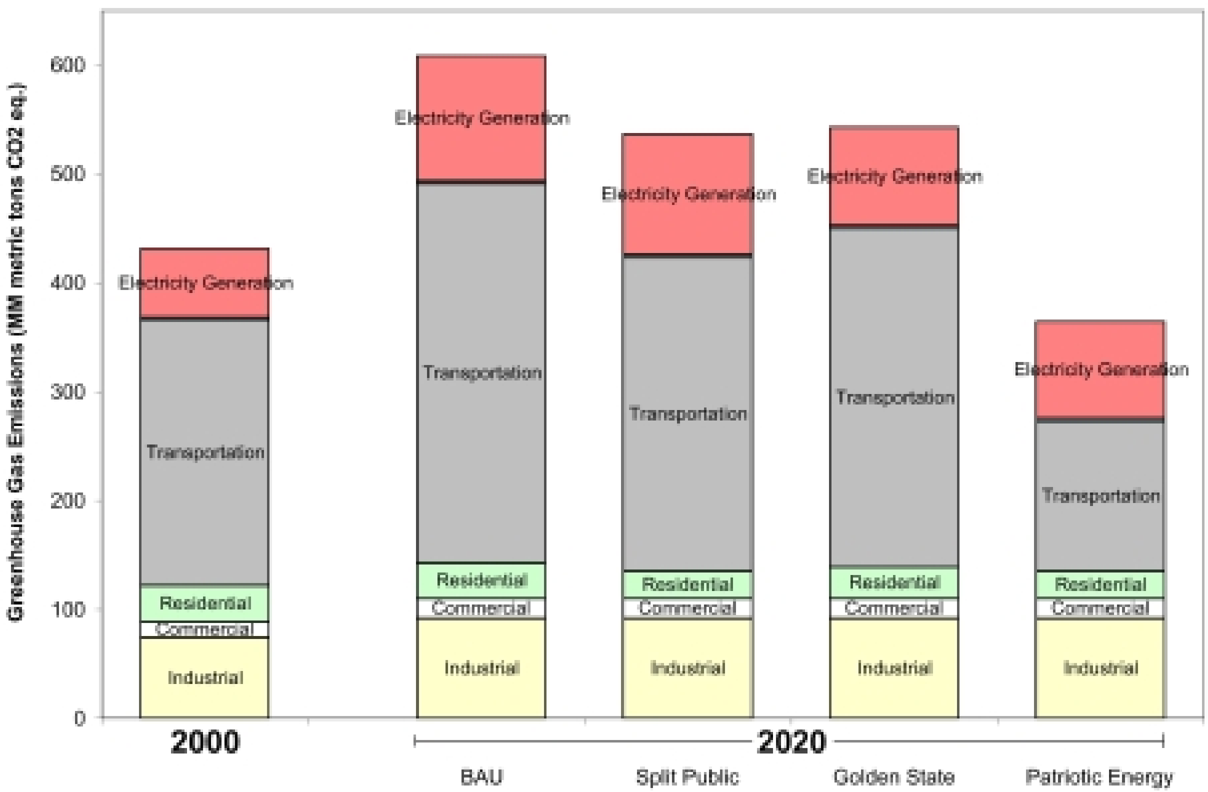
The first observation from these calculations is that the BAU scenario leads to a decrease in energy diversity. This is due primarily to two features: 1) increasing natural gas power generation relative to other fuels and 2) increasing dominance of transportation and oil consumption. The second observation is that all three alternative scenarios show significant improvements in energy diversity relative to the BAU. Golden State achieves improvements in energy diversity primarily by diversifying its power sector and to a lesser extent by transportation and residential activities. Split Public shows somewhat greater energy diversity improvements over Golden State. In this scenario, the power sector is not changed from BAU expectations, rather Split Public improves energy diversity through energy savings. These savings materialize from residential energy efficiency and renewable energy power generation and use of more efficient, hybrid and electric vehicles. Patriotic Energy demonstrates the greatest energy diversity of all of the scenarios. It is a scenario where sweeping transportation changes, along with diversification of the power sector, and residential and commercial efficiency and distributed generation activities all lead to greater overall energy diversity.

3.12 Implications for Greenhouse Gas Emissions

With one of the most mobile populations and a level of economic activity equivalent to some of the most developed countries in the world, California is responsible for a significant level of greenhouse gas emissions. The climate change implications of greenhouse gas emissions are global in scope, and the reduction of greenhouse gas emissions is one the most critical, global environmental challenges facing the world today. In this context, California faces pressure both from within and outside of its borders to enhance its monitoring and mitigation of greenhouse gas emissions. To successfully reduce emissions, the state will need to pursue alternatives to its business-as-usual energy pathway.

This analysis considers the greenhouse gas implications of the three alternative scenarios developed in this paper. These scenarios do not attempt to represent the full potential of greenhouse gas reduction in the state nor present a comprehensive inventory of greenhouse gas emissions. A comprehensive assessment would require a much more detailed analysis and modeling of an extensive set of activities for each sector as well as treatment of non-combustion related emissions and sinks. Rather, this analysis takes on the more modest objective of estimating the greenhouse gas emissions of three alternative scenarios, each representing a small set of alternative activities. By examining how simple sets of alternative activities lead to different future emissions from business-as-usual expectations, the goal is to inspire discussion and critical examination of alternative possibilities for the future. These scenarios serve as an interesting starting point in visualizing alternatives to California's current business-as-usual pathway.

Figure 3.21 Scenario Greenhouse Gas Emissions: Base Year and 2020



Estimates of greenhouse gas emissions for the BAU and three alternative scenarios relative to the base year were derived using IPCC tier one emissions factors for fuel consumption in each sector, and do not take into account non-combustion related emissions or sinks (see earlier methods discussion). Notably, emissions in the BAU scenario in 2020 are more than 40% greater than in the base year. Each of the alternative scenarios has lower emissions than the business-as-usual scenario. Only Patriotic Energy has a lower level of emissions than the base year. Using a California Energy Commission estimate of 1990 gross emissions (CEC, 2001b), Patriotic Energy greenhouse gas emissions in 2020 are 14% below 1990 levels. BAU, Split Public and Golden State emissions in 2020 are greater than 1990 levels by 43%, 26%, and 28% respectively.

Table 3.15. Total In-State Greenhouse Gas Emissions (million metric tons CO2 equivalents)

	1990[1]	2000	2010	2020	% Change 2000-2020	% Change 1990-2020*
BAU	425	431	521	608	41%	43%
Split Public			478	537	24%	26%
Golden State			496	543	26%	28%
Patriotic Energy			429	364	-15%	-14%

Notes: (1)1990 value from California Energy Commission draft report, *Inventory of California greenhouse Gas Emissions and Sinks: 1990-1999*, (CEC, 2001b)

Greenhouse gas emissions in California are dominated by transportation. This sector makes up more than 50% of emissions in the base year. Transportation emissions increase dramatically in the BAU, Split Public, and Golden State scenarios between 2000 and 2020. Only the Patriotic Energy scenario shows a decrease in transportation emissions. It is interesting to note that the assumption of 50% penetration of hybrid and electric cars and light duty trucks in Split Public is not sufficient to offset increasing emissions from population growth and increasing driving activity. Only in Patriotic Energy, where fossil fuel powered cars and light duty trucks are fully displaced by fuel cells, hybrid, and electric vehicles and aggressive freight fuel economy standards are adopted do transportation emissions decrease significantly overall by 44%. This result reinforces the importance of transportation to the state's energy pathway.

Another interesting result is the significantly lower level of emissions from the electricity generation sector between Split Public and Golden State. Emissions increase in both cases, however emissions from the power sector are much lower in Golden State than in Split Public. The Golden State scenario implements a renewable portfolio standard policy and reduces the level of expected new construction of natural gas power plants. The result is significantly lower emissions relative to Split Public which maintains business-as-usual activity in the power generation sector.

Table 3.16 Change in Greenhouse Gas Emissions by Sector, 2000 to 2020 (%)

	% Change in Emissions 2000-2020			
	BAU	Split Public	Golden State	Patriotic Energy
In-State Emissions				
Residential	-1%	-23%	-14%	-23%
Transportation	43%	18%	27%	-44%
Commercial	24%	24%	24%	24%
Industry	24%	24%	24%	24%
Other	9%	9%	9%	9%
Electricity Generation	82%	76%	44%	41%
Total	41%	24%	26%	-15%

An important dimension of greenhouse gas emission in California is the significant fraction of electricity imported from out of state. Between 1998 and 2000, California imported between 22% and 30% of its electricity requirements. (CEC, 2002d). This included varying levels of imports from the Pacific Northwest and southwest (10-18%) and a more or less constant level of imports from investor-owned, out of state coal generation plants that supply electricity exclusively to California (10-12%). Emissions from electricity imports need to be taken into account within California's inventory of greenhouse gas emissions, as they are associated with energy services consumed in California. The large fraction of electricity imports derived from fossil fuels, particularly coal, creates a situation where imports are an important part of the state's overall greenhouse gas emissions from the use of electricity.

Table 3.17 Electricity Imports and Greenhouse Gas Emissions

	Base Year	BAU	Split Public	Golden State	Patriotic Energy
	2000		2020		
Electricity Generation Emissions In-State	63	115	111	91	89
Imported Electricity Emissions					
Limited coal imports[2] (30 TWh/year)	30	30	30	30	-
% of in-state	*48%*	*26%*	*27%*	*33%*	
All coal imports[3] (variable)	62	39	37	7	-
% of in-state	*100%*	*130%*	*120%*	*22%*	
Net Export Emissions[4]	0	0	0	0	-21
Overall increase in gross emissions due to import accounting is 5% to 15%.					

Notes: Electricity generation (coal) emissions factor: 92.644metric tons CO_2 /TJ coal consumed
(1) - Limited coal imports: Assumes fossil fuel derived electricity imports at the current level of fixed-coal imports (30,000 GWh, 33% conversion efficiency).
(2) - All coal imports: Assumes all electricity imports are derived from coal-fired power plants
(3) - Patriotic Energy assumes California becomes a net exporter of electricity.

The table above summarizes a set of calculations estimating the greenhouse gas emissions from electricity imports for each of the scenarios and the base year. If the state were to continue import electricity derived from coal at the current level of investor-owned, out of state coal imports, total emissions from electricity generation would be 26% to 48% higher than in-state generation only (assuming all other imports were derived from non-emitting sources). If the state were to import all of its electricity from coal-based generators, total emissions from electricity generation would be 22% to 130% higher than in-state generation only. The actual level of emissions derived from imports is likely fall somewhere between these two levels. Looking at gross emissions in the state, accounting for imports is estimated to increase the level of emissions by 5% to 15% overall.

The form and timeline of future climate change mitigation strategies and activities in California is a critical uncertainty in the state's future energy pathway. These scenarios demonstrate that emissions are expected to increase significantly along a business-as-usual future. Reducing these emissions will require the state to deviate from a business-as-usual pathway. Using a small set of alternative activities, these scenarios show that emissions reductions are possible. This paper aims to open the door to consideration of alternatives.

Conclusion

Energy scenarios provide an opportunity to learn something about the greater context of current choices and priorities and inform our understandings of the future. In the process of developing scenarios and exploring their implications, certain features come to the forefront, relationships become more visible, and opportunities and challenges become more apparent. This project concludes by presenting a synopsis of some of the key implications and considerations which emerged from the scenario analysis. These idea serve as a both a summary of the scenario findings and a call for active and critical examination of the context and implications of future choices in California.

Critical Issues:

CALIFORNIA IS ON A FOSSIL FUEL PATHWAY. California is on a pathway of decreasing energy diversity and increasing fossil fuel dependence. Fossil fuels currently comprise more than 75% of primary energy demand. More vehicles, more driving activity, and more natural gas power plants are taking California down a pathway toward even greater reliance on fossil fuels. To incorporate energy diversity into the state's future pathway, California must actively pursue alternative fuels and energy efficiency activities.

TRANSPORTATION IS THE MAJOR ENERGY CONSUMER AND POLLUTER IN THE STATE. Transportation accounts for 51% of energy consumption, claims responsibility state oil dependence, and is implicated in the state's most serious air quality and land use issues. Transportation activity and energy consumption is expected to grow substantially faster than either population or the economy in the future. Implementation of a progressive transportation policy framework on both the state and federal level is needed to provide the foundation for addressing the enormous challenge posed by transportation.

CALIFORNIA'S POWER SECTOR IS BECOMING LESS DIVERSE. The state is entering a time where natural gas will dominate the power sector. Significant dependence on natural gas has serious implications for air quality, risk exposure, and balance of fuel and electricity trade. Given the magnitude of change this involves, the state needs to carefully consider and evaluate the costs and benefits associated with this pathway and actively consider alternatives which would increase diversity, such as demand side management and distributed generation.

ALTERNATIVE PATHWAYS TO BUSINESS-AS-USUAL EXPECTATIONS ARE FEASIBLE AND LIKELY. California has a history of being a leader in energy innovation and policy. With a combination of public interest, industry cooperation, and policy leadership, California has enormous opportunities for pursuing cleaner energy pathways on both local and regional levels. With the pressures associated with continuing down a fossil fuel pathway ever increasing, alternative pathways will likely be viewed less "alternative" and more "necessary" in the future. Recognizing the value of alternatives now, captures numerous gains of earlier adoption. Coherent priorities and cooperative engagement are will develop a vision for the future – participatory planning activities provide a starting point for this cooperation.

Priorities and Opportunities:

VEHICLES, VEHICLES, VEHICLES: TRANSPORTATION ACTIVITIES HAVE THE HIGHEST RETURNS. Cars and trucks are the largest and most energy intensive technology that the average person owns – and California has almost enough cars as people. The sheer number of vehicles and magnitude of driving activity means that small changes have huge impacts. New policies, consumer preferences, or technologies which increase fuel economy or alternative fuel use are huge opportunities for reducing future energy consumption, decreasing pollution, and increasing energy diversity.

INDIVIDUAL AND COMMUNITY ACTIVITIES CAN AND DO MAKE A DIFFERENCE. The scenarios Split Public and Golden State show that consumer preferences, household energy use, and community activities can have as much of an impact on reducing energy consumption and increasing energy diversity as state energy policies. Use of solar water heaters, residential home and commercial solar electricity generation, energy efficiency, and fuel efficient and/or alternative fuel vehicle choices are some important ways that individuals and communities can and do make a huge difference in California's energy pathway. Community leadership may become one of the most critical driving forces for change in the future.

IMPORTS PLAY AN IMPORTANT ROLE IN THE STATE. Energy imports will have a major influence on the availability and composition of fuels serving California's energy demand. With likely increases in dependence on oil and natural gas, the cost and availability of imports from other states and countries will become a highly critical uncertainty in California's energy future. With significant capacity additions expected in California, the role of electricity imports is also uncertain. Consideration of California's interdependence with other states and countries will be critical for the future.

A COMBINED BOTTOM-UP AND TOP-DOWN APPROACH IS THE MOST EFFECTIVE. The scenario analysis showed the greatest decreases in consumption and increases in energy diversity were achieved from combining both state and national policy with individual and community activities. The level of individual responsibility toward energy will be an important factor in the state's pathway. California has vast opportunities for encouraging and facilitating a combination of distributed and centralized energy activities.

Policy Implications:

TRANSPORTATION POLICY IS GOOD POLICY FOR ENERGY AND SECURITY. The magnitude, impacts, and risks of transportation activities and oil consumption provide hearty justification for comprehensive transportation policy. In particular, immediate federal transportation policy is needed to increase fuel economy standards for passenger and freight vehicles, support existing alternative vehicle technologies, and develop Hydrogen fueled vehicles and infrastructure. Avoiding the immediate significance of providing comprehensive transportation policy framework for the future is irresponsible and shortsighted. The scenarios demonstrate that significant and *immediate* alternative transportation activities are needed to achieve decreases in transportation oil-dependence. Early action is imperative. A failure to act passes on the responsibility for innovation and leadership to other countries and future generations who will certainly take on the challenge.

A STATE RENEWABLE ENERGY PLAN CAN PROVIDE A ROADMAP FOR THE FUTURE. In order for California to be a leader in renewable energy, the state needs to articulate its commitment to renewable energy and elaborate the key ways that it will encourage these activities. The state has the opportunity to develop a long-term vision and plan for renewable energy with participation of the public, industry, and other stakeholders. A state renewable energy plan would provide policy makers and planners with a framework and vision for considering potential policies such as a renewable portfolio standard, tax incentives, and long-term contracts as well as necessary activities such as standardization of interconnections, and utility cooperation.

CLIMATE CHANGE POLICY NEEDS TO CONSIDER IN-STATE GENERATION AND IMPORTS. State-level climate change activities and future mitigation policies need to include not only in-state generation but also imports. In Particular, California should not forget the coal it uses on its energy or emissions balance sheets. California imports a significant fraction of its electricity, and a large component of these imports comes from fixed-coal imports of investor-owned out-of-state coal facilities[16]. It is imperative that all sources of generation serving California demand be included in climate change policy. Only by including these sources, will accurate benefits and trade-offs of different climate change mitigation strategies be assessed and implemented.

CALIFORNIA IS NOT AN ISLAND AND NEEDS TO INITIATE REGIONAL COOPERATION AND PLANNING. Imports and exports of energy and fuels mean that California does not operate autonomously. Recently, the Energy Crisis demonstrated the important role of interlinkages with other locations. California needs to take the lead in facilitating joint-cooperative and planning efforts within the region.

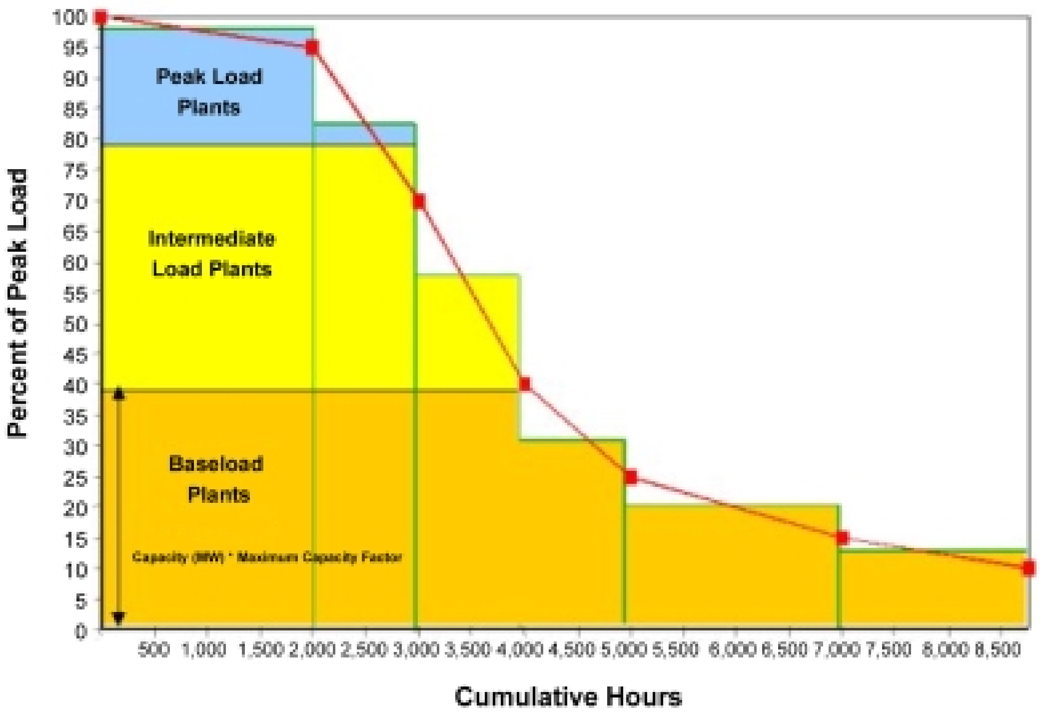
LONG-TERM VISIONING AND COOPERATION STARTS NOW. California has the opportunity to be empowered by what it has learned over the last fifty years on its energy pathway. A critical lesson from the past is that vision and leadership have inspired many of the energy activities that the state is most proud of. In order for a new vision to emerge, it is necessary for the public, industry, government, and other critical stake holders to engage with the future. The state can show leadership in this area by facilitating active discussion, participation, and consideration of alternatives for the future. Essential to this mandate will be for the state to re-establish authority and management for collecting comprehensive energy data. Since deregulation, the mechanisms and responsibilities for collection have become unclear. Now is the time for the state to reorganize its energy planning activities, take charge of information gathering, and incorporate new ideas into its planning and forecasting purview. Scenarios involving participatory methodologies and energy systems modeling are one such opportunity.

In closing, this project demonstrates the potential for “clean” alternative energy pathways which improve energy diversity. In exploring different ways that the future may unfold and ways that California’s energy system may respond to these changes, the aim is to open the door to other possibilities. These scenarios do not predict what the future will be or even what it should be like. Rather they serve as pointers for priorities and opportunities for the future. They show that alternatives are plausible and, in many ways, likely. The objective of this project is to inspire discussion and critical engagement with the intersecting choices and conditions which create California’s future. The methods, tools, and examples provide a framework for beginning this discussion and an opportunity for creative engagement with the future.

[16] Coal generation serving California demand has averaged around 30,000 GWh or 12% of demand between 1998 and 2000. (CEC, 2002d)

APPENDIX

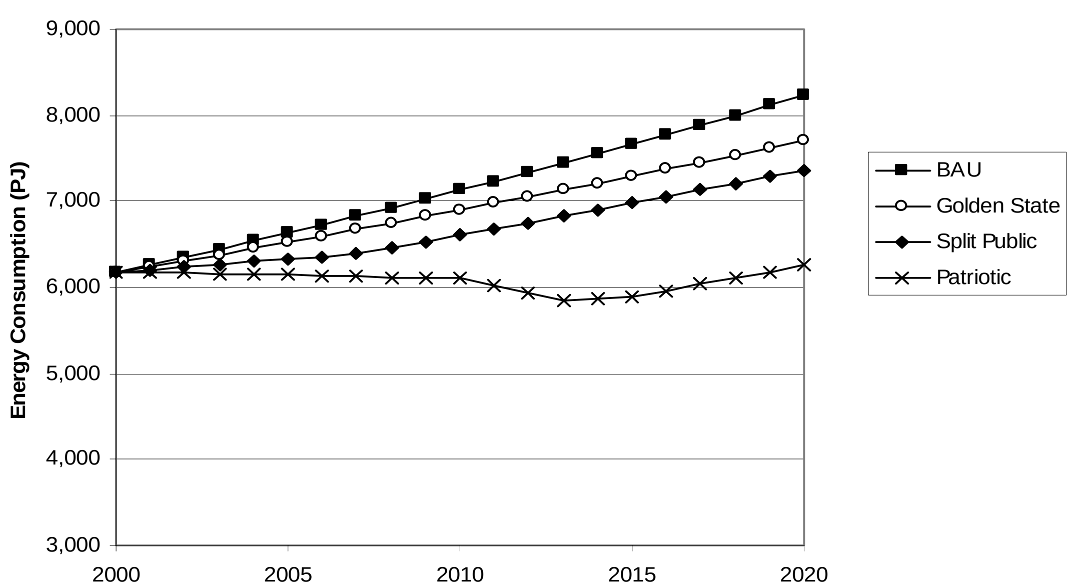
LEAP Model Diagram: Dispatch of Electricity Generation on a Load Curve



from LEAP Users Manual, (SEI, 2001)

Combined Energy Consumption of the Demand Sectors (PJ)

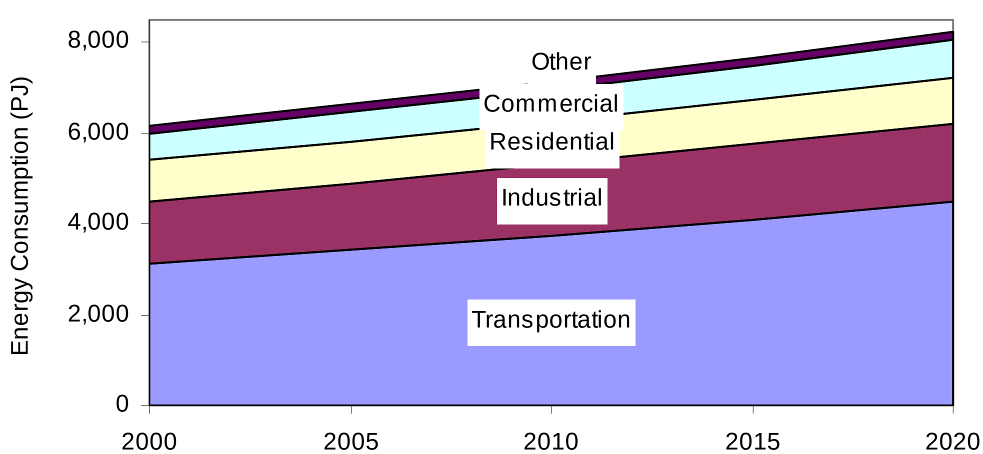
	BAU	Split Public	Golden State	Patriotic Energy
2000	6,171	6,171	6,171	6,171
2001	6,261	6,203	6,240	6,169
2002	6,352	6,234	6,311	6,166
2003	6,445	6,265	6,382	6,161
2004	6,539	6,296	6,453	6,155
2005	6,634	6,327	6,526	6,146
2006	6,731	6,357	6,599	6,135
2007	6,829	6,387	6,673	6,123
2008	6,928	6,458	6,748	6,119
2009	7,029	6,530	6,823	6,113
2010	7,131	6,603	6,899	6,105
2011	7,235	6,676	6,976	6,021
2012	7,340	6,750	7,054	5,931
2013	7,447	6,825	7,132	5,837
2014	7,555	6,901	7,212	5,865
2015	7,665	6,978	7,292	5,894
2016	7,776	7,055	7,372	5,965
2017	7,889	7,132	7,453	6,036
2018	8,003	7,210	7,535	6,108
2019	8,118	7,288	7,617	6,181
2020	8,235	7,367	7,700	6,254



Combined Energy Consumption (PJ): Business-as-Usual

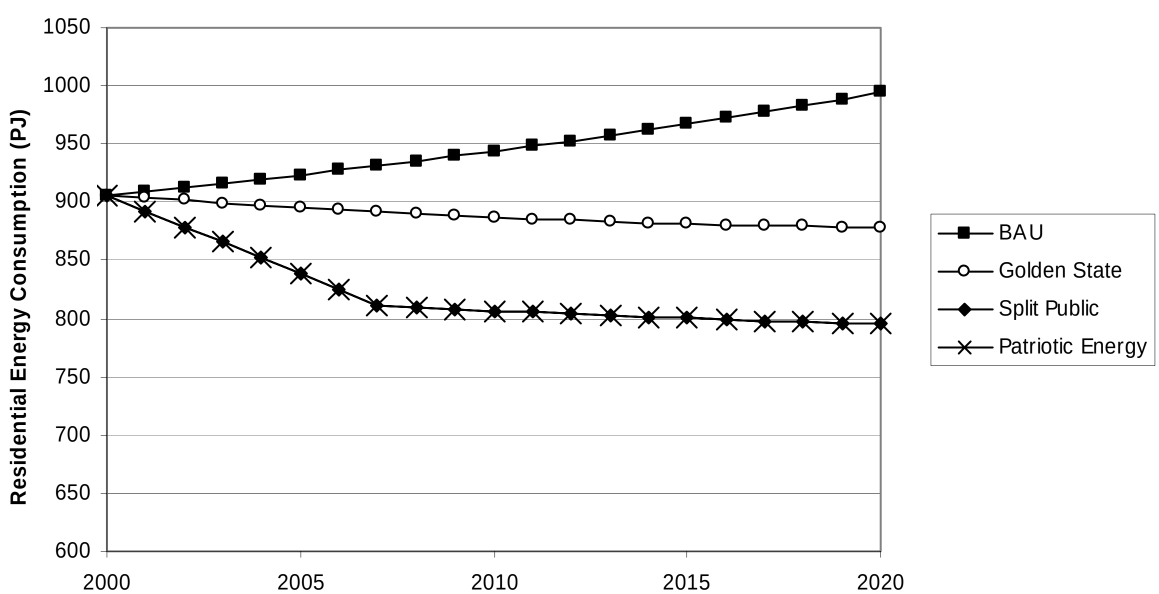
	2000	2005	2010	2015	2020	Growth %/yr	Reference
Transportation	3,126	3,422	3,747	4,105	4,499	1.8%	
Gasoline	1,873	2,030	2,201	2,387	2,589	1.6%	(CEC, 2001)
Jet Fuel	610	687	773	870	980	2.4%	(CEC, 2001)
Diesel	403	440	481	525	573	1.8%	(CEC, 2001)
Residual Fuel Oil	191	209	229	250	274	1.8%	follows driver
Other	49	56	64	74	84	2.8%	
Industry	1,377	1,472	1,564	1,649	1,724	1.1%	
Natural Gas	686	724	754	775	781	0.6%	(CEC, 2002a)
Oil Products	425	458	494	532	573	1.5%	follows activity driver
Electricity	179	197	215	234	252	1.7%	(CEC, 2002a)
Other	87	94	101	109	117	1.5%	follows activity driver
Residential	906	923	944	967	994	0.5%	
Natural Gas	556	552	549	546	543	-0.1%	(CEC, 2002a)
Electricity	286	312	340	371	404	1.7%	(CEC, 2002a)
Biomass	38	31	25	19	13	-5.2%	follows historical 1997-99
Oil Products	26	28	30	32	34	1.3%	follows activity driver
Commercial	594	642	695	755	822	1.6%	
Electricity	337	371	409	453	502	2.0%	(CEC, 2002a)
Natural Gas	235	248	261	275	291	1.1%	(CEC, 2002a)
Other	22	23	25	27	29	1.5%	follows driver
Other	168	174	181	188	196	0.8%	
Electricity	127	133	138	145	151	0.9%	(CEC, 2002a)
Natural Gas	41	42	43	44	45	0.5%	(CEC, 2002a)
Sum	6,171	6,613	7,092	7,610	8,168	1.4%	

	2000	2005	2010	2015	2020
Transportation	3,126	3,422	3,747	4,105	4,499
Industrial	1,377	1,472	1,564	1,649	1,724
Residential	906	923	944	967	994
Commercial	594	642	695	755	822
Other	168	174	181	188	196



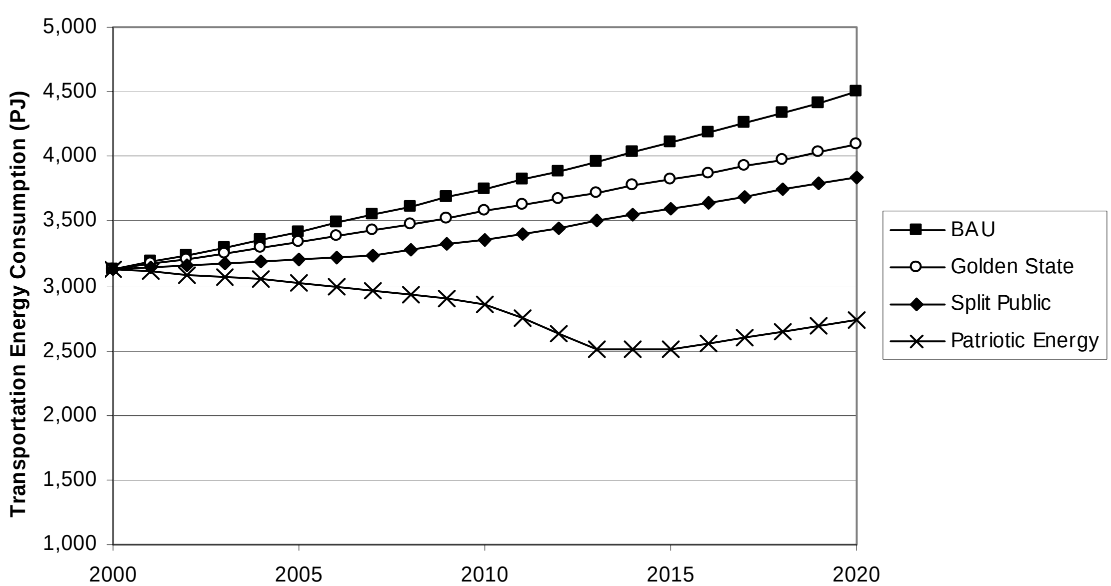
Residential Energy Consumption (PJ)

	BAU	Split Public	Golden State	Patriotic Energy
2000	906	906	906	906
2001	910	893	904	893
2002	913	879	902	879
2003	916	865	900	865
2004	920	852	897	852
2005	923	839	895	839
2006	927	825	894	825
2007	931	812	892	812
2008	935	810	890	810
2009	939	809	889	809
2010	944	807	887	807
2011	948	805	886	805
2012	953	804	885	804
2013	957	803	883	803
2014	962	801	882	801
2015	967	800	882	800
2016	972	799	881	799
2017	978	798	880	798
2018	983	797	880	797
2019	989	797	879	797
2020	994	796	879	796



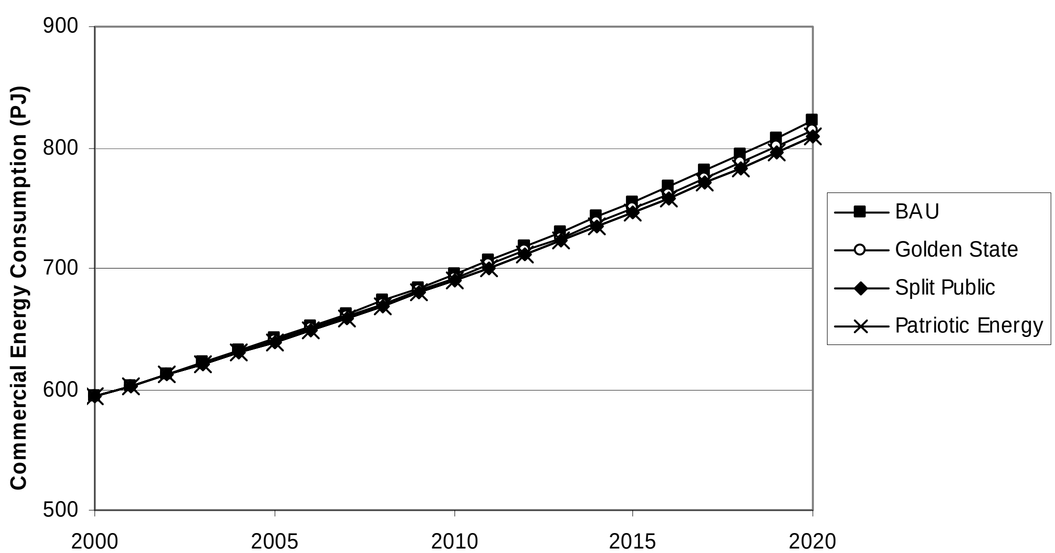
Transportation Energy Consumption (PJ)

	BAU	Split Public	Golden State	Patriotic Energy
2000	3,126	3,126	3,126	3,126
2001	3,183	3,142	3,168	3,109
2002	3,241	3,157	3,211	3,090
2003	3,300	3,173	3,255	3,069
2004	3,360	3,188	3,299	3,046
2005	3,422	3,202	3,343	3,021
2006	3,485	3,216	3,389	2,994
2007	3,548	3,230	3,434	2,965
2008	3,614	3,273	3,481	2,934
2009	3,680	3,317	3,528	2,900
2010	3,748	3,362	3,576	2,864
2011	3,816	3,407	3,624	2,751
2012	3,887	3,453	3,673	2,634
2013	3,958	3,499	3,723	2,511
2014	4,031	3,546	3,773	2,510
2015	4,106	3,594	3,824	2,511
2016	4,181	3,643	3,875	2,553
2017	4,259	3,692	3,927	2,596
2018	4,337	3,741	3,980	2,639
2019	4,418	3,792	4,034	2,684
2020	4,499	3,843	4,088	2,729



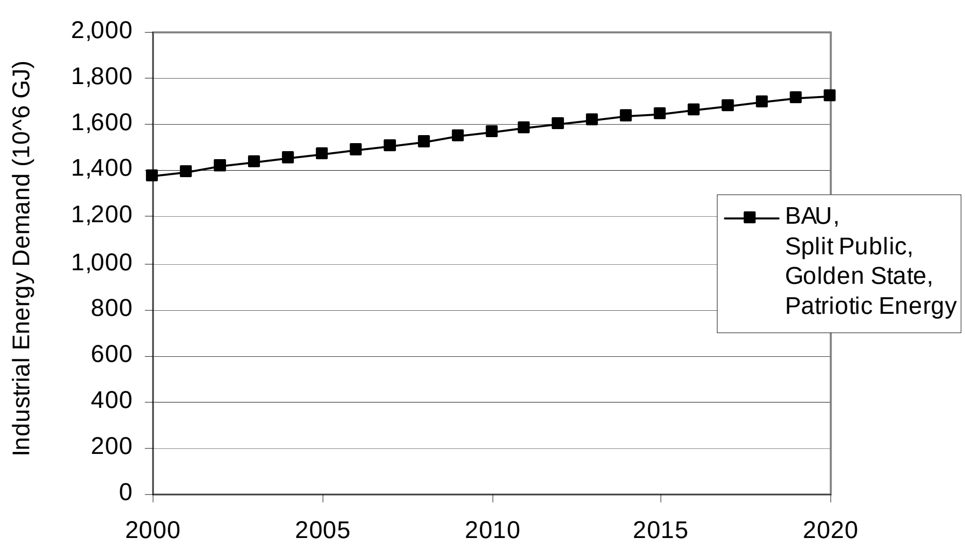
Commercial Energy Consumption (PJ)

	BAU	Split Public	Golden State	Patriotic Energy
2000	594	594	594	594
2001	603	603	603	603
2002	613	612	612	612
2003	622	621	621	621
2004	632	630	631	630
2005	642	639	640	639
2006	652	649	650	649
2007	663	659	660	659
2008	673	669	671	669
2009	684	679	681	679
2010	695	690	692	690
2011	707	701	703	701
2012	719	712	714	712
2013	730	723	726	723
2014	743	735	737	735
2015	755	746	749	746
2016	768	758	762	758
2017	781	771	774	771
2018	794	783	787	783
2019	808	796	800	796
2020	822	809	814	809



Industrial Energy Demand (10^6 GJ)

	BAU	Split Public	Golden State	Patriotic Energy
2000	1,377	1,377	1,377	1,377
2001	1,397	1,397	1,397	1,397
2002	1,416	1,416	1,416	1,416
2003	1,435	1,435	1,435	1,435
2004	1,454	1,454	1,454	1,454
2005	1,472	1,472	1,472	1,472
2006	1,491	1,491	1,491	1,491
2007	1,510	1,510	1,510	1,510
2008	1,528	1,528	1,528	1,528
2009	1,546	1,546	1,546	1,546
2010	1,564	1,564	1,564	1,564
2011	1,581	1,581	1,581	1,581
2012	1,598	1,598	1,598	1,598
2013	1,615	1,615	1,615	1,615
2014	1,632	1,632	1,632	1,632
2015	1,649	1,649	1,649	1,649
2016	1,665	1,665	1,665	1,665
2017	1,681	1,681	1,681	1,681
2018	1,696	1,696	1,696	1,696
2019	1,710	1,710	1,710	1,710
2020	1,724	1,724	1,724	1,724



Electricity Generation by Fuel Type: BAU (TWh)

New/Existing	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2012	2014	2016	2018	2020
Existing WTE	6.2	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
Existing Natural Gas	108.5	114.5	111.1	107.6	102.3	100.2	100.9	101.5	102.1	102.9	103.5	104.8	106.4	107.9	109.6	111.1
Existing Hydro	54.8	53.0	49.8	44.6	39.6	37.5	38.1	38.7	39.3	40.0	40.7	41.9	43.4	44.9	46.4	48.7
Existing Geothermal	12.8	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6
Existing Nuclear	32.7	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0
Existing Coal/Oil	4.2	4.1	4.1	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	4.0
Existing Solar	1.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Existing Wind	3.4	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
New WTE	0.0	0.0	0.3	0.4	0.5	0.6	0.8	0.8	1.1	1.1	1.3	1.5	1.8	2.0	2.4	2.5
NEW CC	0.0	8.6	29.5	47.9	65.9	75.8	79.5	83.1	86.8	90.6	94.4	102.4	110.0	118.0	126.2	133.8
NEW CT	0.0	0.3	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.6
NEW Geothermal	0.0	0.1	0.2	0.3	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.9	2.1	2.3
NEW Small hydro	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.4
New Solar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Wind	0.0	0.3	0.5	0.8	1.0	1.3	1.5	1.8	2.1	2.3	2.6	3.1	3.6	4.1	4.6	5.1
Imports	62.2	49.3	39.6	35.2	32.4	31.8	32.0	32.2	32.4	32.6	32.9	33.8	34.9	36.0	37.3	38.6
TOTAL GENERATION	285.8	290.8	296.2	301.5	306.9	312.5	318.2	323.6	329.4	335.2	341.5	353.8	366.7	379.8	393.6	407.7

Composition of Electricity Generation: BAU (%)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2012	2014	2016	2018	2020
% Natural Gas	38%	42%	48%	52%	55%	56%	57%	57%	57%	58%	58%	59%	59%	60%	60%	60%
% Nuclear	11%	12%	11%	11%	11%	11%	11%	11%	10%	10%	10%	10%	9%	9%	9%	8%
% Hydro	19%	18%	17%	15%	13%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%
% Coal/Oil	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
% Renewable *(non-hydro)*	8%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%
% Imports	22%	17%	13%	12%	11%	10%	10%	10%	10%	10%	10%	10%	10%	9%	9%	9%
% Exports	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Generation (TWh)	285.8	290.8	296.2	301.5	306.9	312.5	318.2	323.6	329.4	335.2	341.5	353.8	366.7	379.8	393.6	407.7

Electricity Generation by Fuel Type: Split Public (TWh)

New/Existing	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2012	2014	2016	2018	2020
Existing WTE	6.2	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
Existing Natural Gas	108.5	114.3	110.7	106.6	101.1	98.9	99.2	99.6	100.2	100.9	101.5	102.6	104.1	105.6	107.1	108.7
Existing Hydro	54.8	52.8	49.4	43.7	38.4	36.2	36.5	36.9	37.5	38.0	38.6	39.9	41.3	42.7	44.2	45.6
Existing Geothermal	12.8	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6
Existing Nuclear	32.7	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0
Existing Coal/Oil	4.2	4.1	4.1	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9
Existing Solar	1.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Existing Wind	3.4	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
New WTE	0.0	0.0	0.3	0.4	0.5	0.6	0.8	0.8	1.1	1.1	1.3	1.5	1.8	2.0	2.4	2.5
NEW CC	0.0	8.5	29.2	46.9	64.2	73.2	76.3	79.3	82.9	86.5	90.2	97.6	104.7	112.2	119.9	128.0
NEW CT	0.0	0.3	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
NEW Geothermal	0.0	0.1	0.2	0.3	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.9	2.1	2.3
NEW Small hydro	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.4
New Solar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Wind	0.0	0.3	0.5	0.8	1.0	1.3	1.5	1.8	2.1	2.3	2.6	3.1	3.6	4.1	4.6	5.1
Imports	62.2	48.7	38.4	34.7	32.1	31.4	31.5	31.6	31.8	32.0	32.1	32.6	33.4	34.4	35.5	36.7
TOTAL GENERATION	285.8	289.7	293.9	298.1	302.5	306.9	311.2	315.5	321.2	326.5	332.3	343.5	355.4	367.9	380.8	394.0

Composition of Electricity Generation: Split Public (%)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2012	2014	2016	2018	2020
% Natural Gas	38%	42%	48%	52%	55%	56%	56%	57%	57%	57%	58%	58%	59%	59%	60%	60%
% Nuclear	11%	12%	12%	11%	11%	11%	11%	11%	11%	10%	10%	10%	10%	9%	9%	9%
% Hydro	19%	18%	17%	15%	13%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%
% Coal/Oil	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
% Renewable *(non-hydro)*	8%	9%	9%	9%	9%	9%	10%	10%	10%	9%	10%	9%	9%	9%	9%	9%
% Imports	22%	17%	13%	12%	11%	10%	10%	10%	10%	10%	10%	9%	9%	9%	9%	9%
% Exports	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Generation (TWh)	285.8	289.7	293.9	298.1	302.5	306.9	311.2	315.5	321.2	326.5	332.3	343.5	355.4	367.9	380.8	394.0

Electricity Generation by Fuel Type: Golden State (TWh)

New/Existing	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2012	2014	2016	2018	2020
Existing WTE	6.2	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
Existing Natural Gas	108.5	106.4	105.5	104.4	101.9	101.2	102.2	103.2	104.3	105.3	106.3	105.4	104.0	102.5	101.0	99.5
Existing Hydro	54.8	45.3	44.3	41.5	39.2	38.6	39.5	40.5	41.5	42.4	43.5	42.5	41.1	39.7	38.3	36.9
Existing Geothermal	12.8	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6
Existing Nuclear	32.7	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0
Existing Coal/Oil	4.2	4.1	4.1	3.9	3.9	3.9	3.9	3.9	3.9	3.9	4.0	3.9	3.9	3.9	3.9	3.9
Existing Solar	1.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Existing Wind	3.4	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
New WTE	0.0	31.0	31.1	31.3	31.3	31.5	31.6	31.8	31.9	32.0	32.0	37.8	45.1	52.7	60.7	69.0
NEW CC	0.0	3.6	13.1	22.3	32.6	38.8	41.0	43.2	45.6	47.9	50.3	52.0	52.1	52.1	51.9	51.6
NEW CT	0.0	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
NEW Geothermal	0.0	0.1	0.2	0.3	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.9	2.1	2.3
NEW Small hydro	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3
New Solar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Wind	0.0	28.9	29.2	29.5	29.7	30.0	30.2	30.5	30.7	31.0	31.3	36.8	43.9	51.2	58.7	66.7
Imports	62.2	10.4	7.1	6.3	5.2	4.8	5.3	5.8	6.3	6.8	7.3	7.3	7.2	7.1	6.9	6.8
TOTAL GENERATION	285.8	290.6	295.4	300.3	305.1	310.2	315.2	320.5	325.9	331.2	336.8	348.0	359.8	372.1	384.5	397.7

Composition of Electricity Generation: Golden State (%)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2012	2014	2016	2018	2020
% Natural Gas	38%	38%	40%	42%	44%	45%	45%	46%	46%	46%	47%	45%	43%	42%	40%	38%
% Nuclear	11%	12%	12%	11%	11%	11%	11%	11%	10%	10%	10%	10%	9%	9%	9%	9%
% Hydro	19%	16%	15%	14%	13%	12%	13%	13%	13%	13%	13%	12%	11%	11%	10%	9%
% Coal/Oil	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
% Renewable *(non-hydro)*	8%	30%	29%	29%	29%	29%	28%	28%	28%	27%	27%	29%	33%	36%	39%	41%
% Imports	22%	4%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
% Exports	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Generation (TWh)	285.8	290.6	295.4	300.3	305.1	310.2	315.2	320.5	325.9	331.2	336.8	348.0	359.8	372.1	384.5	397.7

Electricity Generation by Fuel Type: Patriotic Energy (TWh)

New/Existing	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2012	2014	2016	2018	2020
Existing WTE	6.2	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
Existing Natural Gas	108.5	104.2	103.3	102.0	99.8	104.5	103.9	103.1	102.2	101.5	100.6	99.0	97.6	96.9	96.3	95.9
Existing Hydro	54.8	43.3	41.2	39.3	37.3	41.6	41.0	40.4	39.6	38.8	38.0	36.4	35.2	34.5	34.0	33.6
Existing Geothermal	12.8	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6
Existing Nuclear	32.7	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0
Existing Coal/Oil	4.2	4.1	4.0	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9
Existing Solar	1.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Existing Wind	3.4	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
New WTE	0.0	36.6	36.8	36.9	37.0	38.5	41.4	44.2	47.8	51.5	55.3	63.3	69.9	73.6	76.6	79.4
NEW CC	0.0	3.5	12.5	21.1	31.0	41.9	42.5	43.1	43.4	43.8	44.1	44.4	44.4	45.1	46.0	46.9
NEW CT	0.0	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
NEW Geothermal	0.0	0.1	0.2	0.3	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.9	2.1	2.3
NEW Small hydro	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3
New Solar	0.0	5.4	5.4	5.4	5.4	5.6	6.0	6.4	6.9	7.5	8.0	9.1	10.1	10.6	11.0	11.4
New Wind	0.0	34.2	34.5	34.7	35.0	36.5	39.2	42.1	45.6	49.2	52.7	60.5	66.9	70.5	73.6	76.5
Imports	62.2	8.3	6.8	6.1	5.0	7.1	7.1	7.0	6.9	6.8	6.8	6.6	6.5	6.4	6.3	6.3
TOTAL GENERATION	285.8	300.5	305.4	310.4	315.7	341.0	346.5	351.8	358.0	364.8	371.5	385.5	397.0	404.3	410.8	417.2

Composition of Electricity Generation: Patriotic Energy (%)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2012	2014	2016	2018	2020
% Natural Gas	38%	36%	38%	40%	41%	43%	42%	42%	41%	40%	39%	37%	36%	35%	35%	34%
% Nuclear	11%	11%	11%	11%	11%	10%	10%	10%	9%	9%	9%	9%	9%	8%	8%	8%
% Hydro	19%	14%	13%	13%	12%	12%	12%	12%	11%	11%	10%	9%	9%	9%	8%	8%
% Coal/Oil	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
% Renewable *(non-hydro)*	8%	34%	34%	33%	33%	32%	33%	34%	36%	37%	39%	42%	44%	45%	46%	47%
% Imports	22%	3%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
Generation (TWh)	285.8	300.5	305.4	310.4	315.7	341.0	346.5	351.8	358.0	364.8	371.5	385.5	397.0	404.3	410.8	417.2
% Exports	0%	3%	3%	3%	3%	9%	9%	9%	8%	8%	8%	8%	8%	7%	7%	7%

California Scenarios Energy Balance by Fuel - Selected Years

Base Year, 2000 (PJ)

		Primary Energy Consumption (PJ)								Total Primary Energy
	Electricity	Imports*	Oil Products	Coal & Coke	Natural Gas	Hydro	Renewables	Alcohol	Nuclear	
Electricity Generation	805		65	17	1009	597	275	0	368	2,331
Transmission & Dist.	-98									
Net In-State Generation	707									
Electricity Imports	224	672								672
Electricity Exports	0									0
Households	286		26	0	556	0	38	0	0	620
Industry	179		425	51	686	0	36	0	0	1198
Commercial	337		15	0	235	0	6	0	0	256
Transportation	2		3,102	0	16	0	0	5	0	3123
Other	127		0	0	41	0	0	0	0	41
Total	931	672	3,633	68	2,543	597	355	5	368	8,241

Business-as-Usual, 2020 (PJ)

		Primary Energy Consumption (PJ)								Total Primary Energy
	Electricity	Imports*	Oil Products	Coal & Coke	Natural Gas	Hydro	Renewables	Alcohol	Nuclear	
Electricity Generation	1,329		68	19	1928	536	465	0	382	3,398
Transmission & Dist.	-139									
Net In-State Generation	1,190									
Electricity Imports	139	417								417
Electricity Exports	0									
Households	404		34	0	543	0	13	0	0	590
Industry	252		573	69	781	0	48	0	0	1471
Commercial	502		21	1	291	0	8	0	0	321
Transportation	19		4,451	0	22	0	0	7	0	4480
Other	151		0	0	45	0	0	0	0	45
Total	1,328	417	5,147	89	3,610	536	534	7	382	10,722

Note: Total primary energy accounts for direct consumption of primary fuels by demand sectors and electricity generation (i.e. it accounts for natural gas used to generate electricity, not electricity itself). It also estimates primary energy of electricity imports, assuming a 33% efficiency for imported electricity generation.

California Scenarios Energy Balance by Fuel - Selected Years

Split Public, 2020 (PJ)

		Primary Energy Consumption (PJ)								Total Primary	Savings vs.
	Electricity	**Imports***	**Oil Products**	**Coal & Coke**	**Natural Gas**	**Hydro**	**Renewables**	**Alcohol**	**Nuclear**	**Energy**	**BAU 2020**
Electricity Generation	1,287		67	19	1,858	502	465	0	382	3,293	
Transmission & Dist.	-135										
Net In-State Generation	1,152										
Electricity Imports	132	396								396	
Electricity Exports	0										
Households	339		34	0	410	0	13	0	0	457	
Industry	252		573	69	781	0	48	0	0	1,471	
Commercial	489		21	1	291	0	8	0	0	321	
Transportation	53		3,759	0	24	0	0	7	0	3,790	
Other	151		0	0	45	0	0	0	0	45	
Total Primary Energy		396	4,454	89	3,409	502	534	7	382	9,773	949

Golden State, 2020 (PJ)

		Primary Energy Consumption (PJ)								Total Primary	Savings vs.
	Electricity	**Imports***	**Oil Products**	**Coal & Coke**	**Natural Gas**	**Hydro**	**Renewables**	**Alcohol**	**Nuclear**	**Energy**	**BAU 2020**
Electricity Generation	1,407		172	50	1,290	406	1,681	0	382	3,981	
Transmission & Dist.	-136										
Net In-State Generation	1,271										
Electricity Imports	24	72								72	
Electricity Exports	0										
Households	363		34	0	469	0	13	0	0	516	
Industry	252		573	69	781	0	48	0	0	1,471	
Commercial	494		21	1	291	0	8	0	0	321	
Transportation	35		4,023	0	23	0	0	7	0	4,053	
Other	151		0	0	45	0	0	0	0	45	
Total Primary Energy		72	4,823	120	2,899	406	1,750	7	382	10,459	263

Note: Total primary energy accounts for direct consumption of primary fuels by demand sectors and electricity generation (i.e. it accounts for natural gas used to generate electricity, not electricity itself). It also estimates primary energy of electricity imports, assuming a 33% efficiency for imported electricity generation.

California Scenarios Energy Balance by Fuel - Selected Years

Patriotic Energy, 2020
(PJ)

	Electricity	Primary Energy Consumption (PJ) Imports*	Oil Products	Coal & Coke	Natural Gas	Hydro	Renewables	Alcohol	Nuclear	Total Primary Energy	Savings vs. BAU 2020
Electricity Generation	1,479		188	56	1,226	369	1,997	0	382	4,218	
Transmission & Dist.	-132										
Net In-State Generation	1,347										
Electricity Imports	23	69								69	
Electricity Exports	-108										
Households	339		34	0	410	0	13	0	0	457	
Industry	252		573	69	781	0	48	0	0	1,471	
Commercial	489		21	1	291	0	8	0	0	321	
Transportation	30		1,869	0	26	0	798	7	0	2,700	
Other	151		0	0	45	0	0	0	0	45	
Total Primary Energy		69	2,685	126	2,779	369	2,864	7	382	9,281	1,441

Note: Total primary energy accounts for direct consumption of primary fuels by demand sectors and electricity generation (i.e. it accounts for natural gas used to generate electricity, not electricity itself). It also estimates primary energy of electricity imports, assuming a 33% efficiency for imported electricity generation.

*** The energy savings category is savings relative to BAU 2020

California Scenarios Greenhouse Gas Emissions Estimate - by Year

Business-as-Usual - Global Warming Potential (million metric ton CO_2 equivalents)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2012	2014	2016	2018	2020
In-State Emissions																
Commercial	14	15	15	15	15	15	15	16	16	16	16	16	17	17	18	18
Residential	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33
Industry	74	75	76	77	78	79	80	81	82	83	84	86	87	89	91	92
Other	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3
Transportation	244	249	253	257	262	267	271	276	281	286	291	302	313	324	336	348
Electricity Generation	63	70	75	80	83	86	87	89	91	93	95	98	102	106	111	115
Total	431	444	455	465	474	482	490	497	505	513	521	538	555	572	590	608
Electricity Import Emissions																
Limited coal imports (30 TWh/year)	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
All coal imports (variable)	62	49	40	35	32	32	32	32	32	33	33	34	35	36	37	39
Gross Emissions																
In-State only (no imports)	431	444	455	465	474	482	490	497	505	513	521	538	555	572	590	608
In-State + limited coal imports	461	474	485	495	504	512	520	528	535	543	552	568	585	602	620	639
In-State + all coal imports	493	493	494	500	506	514	522	530	538	546	554	572	590	608	627	647

Split Public (PJ) - Global Warming Potential (million metric ton CO2 equivalents)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2012	2014	2016	2018	2020
In-State Emissions																
Commercial	14	15	15	15	15	15	15	16	16	16	16	16	17	17	18	18
Residential	33	33	32	31	30	30	29	28	28	28	28	27	27	26	26	26
Industry	74	75	76	77	78	79	80	81	82	83	84	86	87	89	91	92
Other	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3
Transportation	244	245	245	246	246	247	247	247	250	253	256	262	268	275	281	288
Electricity Generation	63	70	75	79	82	84	85	87	88	90	92	95	99	103	107	111
Total	431	439	445	450	454	457	459	461	466	472	478	489	501	512	524	537
Electricity Import Emissions																
Limited coal imports (30 TWh/year)	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
All coal imports (variable)	62	49	38	35	32	31	31	32	32	32	32	33	33	34	36	37
Gross Emissions																
In-State (no imports)	431	439	445	450	454	457	459	461	466	472	478	489	501	512	524	537
In-State + limited coal imports	461	469	476	480	484	487	489	491	496	502	508	519	531	543	555	567
In-State + all coal imports	493	487	484	485	486	488	490	492	498	504	510	522	534	547	560	573

Note: Limited coal imports: Assumes fossil fuel derived electricity imports at the current level of fixed-coal imports (30,000 GWh, 33% conversion efficiency).

All coal imports: Assumes all electricity imports are derived from coal-fired power plants

Electricity generation (coal) emissions factor: 92.644 metric tons CO_2 /TJ coal consumed

California Scenarios Greenhouse Gas Emissions Estimate - by Year

Golden State - Global Warming Potential (million metric ton CO2 equivalents)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2012	2014	2016	2018	2020
In-State Emissions																
Commercial	14	15	15	15	15	15	15	16	16	16	16	16	17	17	18	18
Residential	33	33	33	33	32	32	32	32	31	31	31	31	30	30	29	29
Industry	74	75	76	77	78	79	80	81	82	83	84	86	87	89	91	92
Other	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3
Transportation	244	247	250	253	256	260	263	266	269	273	276	283	290	297	304	311
Electricity Generation	63	69	72	75	77	79	80	82	83	85	87	88	89	89	90	91
Total	431	442	448	455	461	467	473	478	484	490	496	505	515	524	534	543
Electricity Import Emissions																
Limited coal imports (30 TWh/year)	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
All coal imports (variable)	62	10	7	6	5	5	5	6	6	7	7	7	7	7	7	7
Gross Emissions																
In-State (no imports)	431	442	448	455	461	467	473	478	484	490	496	505	515	524	534	543
In-State + limited coal imports	461	472	479	485	491	497	503	509	514	520	526	536	545	554	564	573
In-State + all coal imports	493	452	455	461	466	472	478	484	490	497	503	513	522	531	540	550

Patriotic Energy - Global Warming Potential (million metric ton CO2 equivalents)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2012	2014	2016	2018	2020
In-State Emissions																
Commercial	14	15	15	15	15	15	15	16	16	16	16	16	17	17	18	18
Residential	33	33	32	31	30	30	29	28	28	28	28	27	27	26	26	26
Industry	74	75	76	77	78	79	80	81	82	83	84	86	87	89	91	92
Other	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3
Transportation	244	242	240	237	234	231	228	225	221	217	213	180	156	148	143	138
Electricity Generation	63	69	72	74	76	84	84	84	85	85	86	86	87	88	88	89
Total	431	436	436	436	437	441	439	436	434	432	429	398	377	370	368	364
Electricity Export Emissions																
Net Exports	62	-2	-5	-5	-7	-30	-29	-29	-28	-27	-27	-24	-22	-22	-21	-21
Gross Emissions																
In-State (no imports)	431	436	436	436	437	441	439	436	434	432	429	398	377	370	368	364
In-State - net exports	493	433	432	431	430	412	410	408	406	404	402	374	354	349	346	344

Note: Limited coal imports: Assumes fossil fuel derived electricity imports at the current level of fixed-coal imports (30,000 GWh, 33% conversion efficiency).

All coal imports: Assumes all electricity imports are derived from coal-fired power plants

Patriotic Energy assumes California becomes a net exporter of electricity

Electricity generation (coal) emissions factor: 92.644 metric tons CO_2 /TJ coal consumed

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